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1986

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FOREWORD

Packaging of Food as a means of preservation is as ancient as human civilization. With the advance of human civilization and improvements in man's techniques, food packaging also changed from using natural materials to man-made materials and has always reflected the socio-economic and technological developments of the society. In our country food packaging played a vital role in reducing spoilage and loss of foods stuffs during storage and transportation. But in western societies it has passed that stage and has become a marketing tool, catering to man's comfort, convenience and psyche. There affluence and technological development have combined to bring a myriad of new packages to the market. Since the last decade we too had its impact in India.

Rapid developments have taken place in the field of food packaging materials and packaging system machineries throughout the world. In India, many of these developments are being introduced, and also many research organisations are engaged in R & D efforts to improve the packing of food products for more attractiveness and improved shelf life for the internal and world markets. In the light of these developments the present symposium was organised with the objective of bringing an overview on the present status and the future requirements of food packaging industry in the country.

Thorough discussions were held at the end of each session and at the end of all the sessions, appropriate recommendations were made for the improvement of food packaging in India.

About 40 papers were presented in four different sessions under the following topics:

I. Materials and forms of packaging

II. Packaging methods and performance

III. Transport packaging

IV. Quality Control and standards.

The developments in metal containers such as welding technology and scope of aluminium containers in food packaging were highlighted. Developments in the field of plastic packaging materials and the problems in their use and disposal were discussed and identified. The details of aseptic packaging for bulk packing of fruit pulps for internal and export markets with special reference to the problems with respect to the shelf life and the quality of the product was discussed. Developments in transport packaging, particularly for the distribution of fruits and vegetables (F & V) was discussed. The cost of transport and the developments of alternate packaging materials now available were discussed and suitable recommendations made. The safety aspects of food packaging materials and the development of suitable test methods and standards were debated.

The cost of printing this volume has been partly met by a grant from the Council of Scientific and industrial Research, to whom we are grateful.

December 1985

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INAUGURAL SESSION

Report on the Inaugural Session

The Association of Food Scientists and Technologists (India) in collaboration with Central Food Technological Research Institute, Mysore, organised a National Symposium on 'Recent Developments in Food Packaging' during 17-18 January 1985, at CFTRI, Mysore. The main objective of the Symposium was to bring out an overview on the present status and the future requirements of food packaging industry in the country.

The Symposium was inaugurated by Prof. K. S. Hegde, Vice Chancellor, University of Mysore. In his inaugural address Prof. Hegde stressed upon the need to consider economics of packaging by reducing costs using modern methods. Safety of food packaging should be of utmost concern, he added. Sri S. K. Majumder, Deputy Director of CFTRI, Mysore, who presided over the inaugural function informed that our country is importing about Rs. 50 crores worth tin plate from other countries for fabricating food cans used for packaging processed food products. This deprives the capacity for indigenous production of tin plate. Delivering the theme of the Symposium Sri. P. V. Raju stated that food industry in the country spends more than Rs. 70 crores on packaging materials and employs more than five million workers in packaging activity.

Earlier Dr. S. S. Arya, Vice President, AFST (I), while welcoming the delegates stressed that packaging is crucial for the food manufacturing industry for safe delivery of processed foods from manufacturers to consumers. He emphasised that food processing industries are affected by the non-availability of quality packaging materials and lack of adequate standards for the packaging materials in the country.

While delivering the key note address Major. N. V. R. Iyengar pointed out that though India has made progress in the field of packaging during the last three decades, scarcity in many raw materials is impeding the progress of the industry.

He also added that package must protect and preserve the product so that it reaches the consumer in as safe and as fresh a condition as it was produced. He pointed out that the key to export promotion is adequate and attractive packaging of the products meant for exports.

Dr. M. Mahadeviah, Hony. Executive Secretary. AFST (I) proposed a vote of thanks to the delegates for their overwhelming response, and to the packaging industry for their support in the form of advertisements, dinners, lunches & teas-etc. in honour of delegates.

About 200 delegates representing the food packaging and processing industries from different parts of the country participated in the Symposium. A few foreign delegates from France and Australia also participated. About forty papers on various aspects of food packaging including Packaging materials and Forms, Performance and shelf life, Transport Packaging, Quality Control and Standards were presented.

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SYMPOSIUM SESSIONS

SESSION I—MATERIALS AND FORMS OF PACKAGING

Chairman: Major N. V. R. Iyengar
Co-Chairman: Dr. S. S. Arya

Rapporteurs: Sri. K. R. Kumar
Mrs. A. R. Indiramma

The Welded Can

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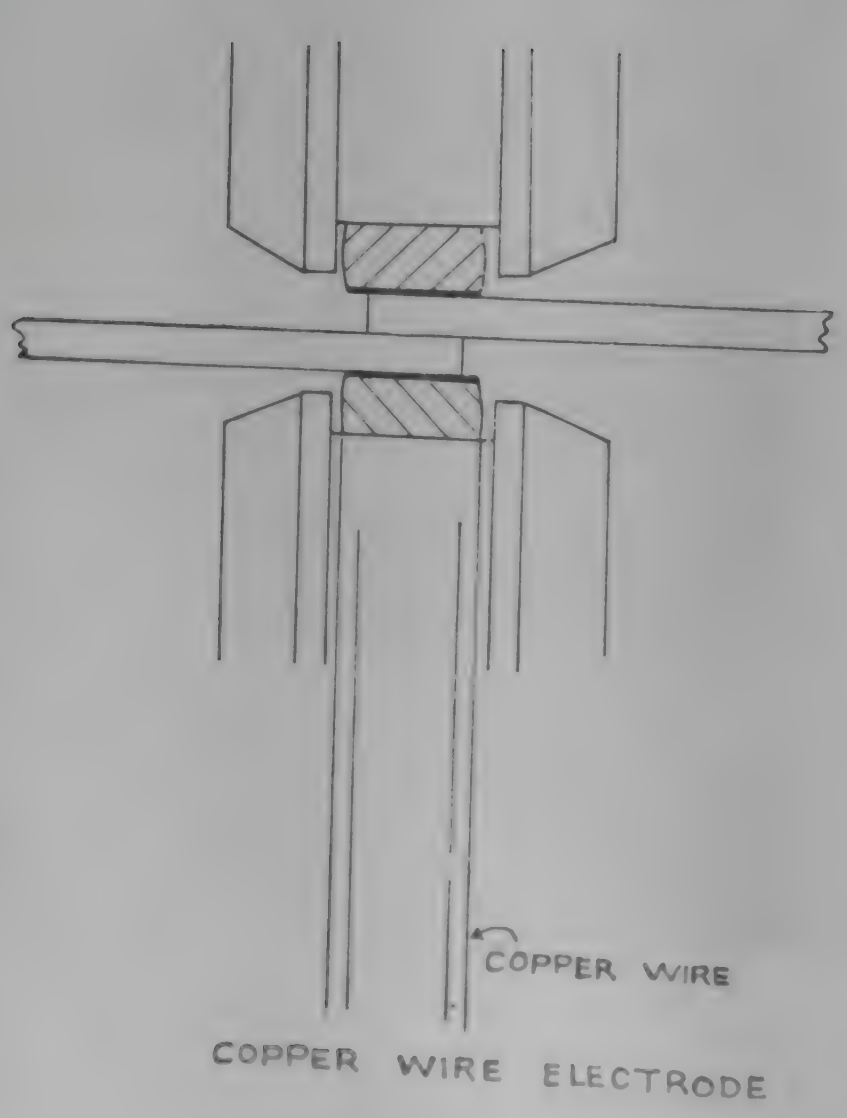
ABSTRACT

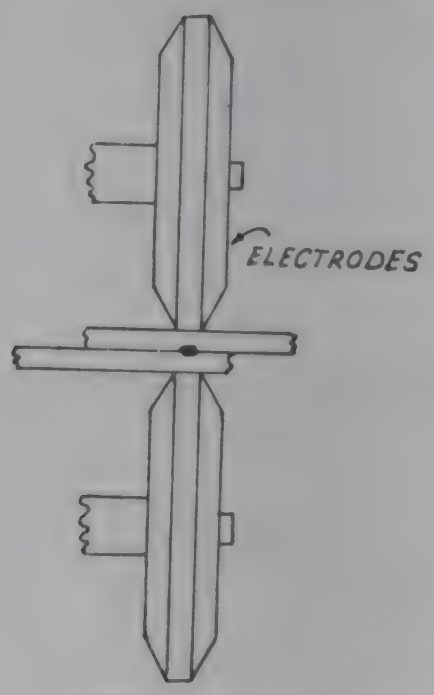
A brief introduction on welding of metal and its development is given. The advantages of welded can over soldered can have been explained. The various new technologies available for metal can making have been mentioned.

Introduction

The welding of metal is a very old technique, but its application to the tinplate can was done in 1960's in Europe and America. There were two types of welding processes available, both based on resistance welding.

1. The copper roll electrode
2. Continuous renewed copper wire electrode.





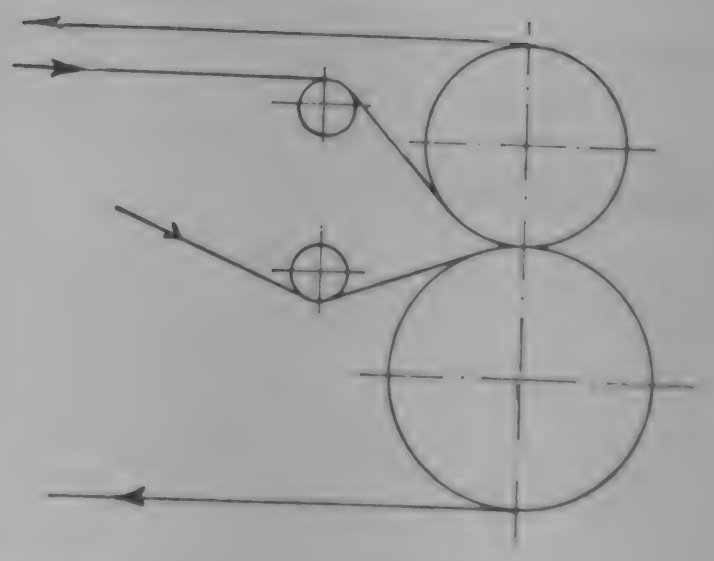


Fig. 1. Copper wire and copper roll electrodes.

The trouble with process (1) was that the copper roll got contaminated with tin and oxides and the machine needed frequent cleaning of the rolls resulting in stoppages and the quality of the weld was poor. This problem was overcome in process (2) by the introduction of continuously renewed copper wire as an intermediate electrode. This process was developed by a Swiss Company and was called the 'butterfly weld'. Initially large volume containers for general line and aerosol containers were made using this type of weld. This type of weld is also in use in India for quite a few years for general line containers. This welding process was improved in 1975 by the same Swiss Company with the introduction of Wima (wire mash) weld and further still in 1978 with the introduction of what is called as 'Superwima' weld. It is the introduction of Superwima Weld that has given real thrust to the use of welded tinplate cans for beverage and process foods. Increase in welding speed has also helped this process.

Types of Weld

The different types of weld are given in figure 2.

In the case of butterfly weld there is a large plate overlap of about 3 to 4 mm and the thickness of the plate at the seam weld is nearly double and there is a distinct step. This step can give problems of leakage at double seam juncture and also corrosion problems along the cut edges of the step as it is difficult to cover it even with a lacquer.

In the case of Wima both the overlap and the weld thickness has been reduced further. And in fhe case of Superwima the weld thickness has been turther reduced to about 1.3 times in plate thickness and the plate overlap to about 0.4 mm. The actual weld width may vary between 0.4 to 0.5 mm. because of pressing in body blank cut edges. The mechanism of welding is as follows:

The resistance of tinplate being much higher than that of copper wire electrode, the tinplate heats quickly to the required fusion temperature which joins the two edges of the tinplate together to a neat welded seam. This is nothing but a continuous spot welding with overlapping nuggets which gives a leak-proof seam.

The narrow overlap in Superwima process consumes less energy and produces less heat which gives better quality weld metallurgically and improves flanging operation. The tensile strength of weld is equal to the strength of plate used which makes further shaping operation of can such as beading, necking etc. easy. The strength of the weld seam is demonstrated by reverse flanged can as shown in Fig. 3.

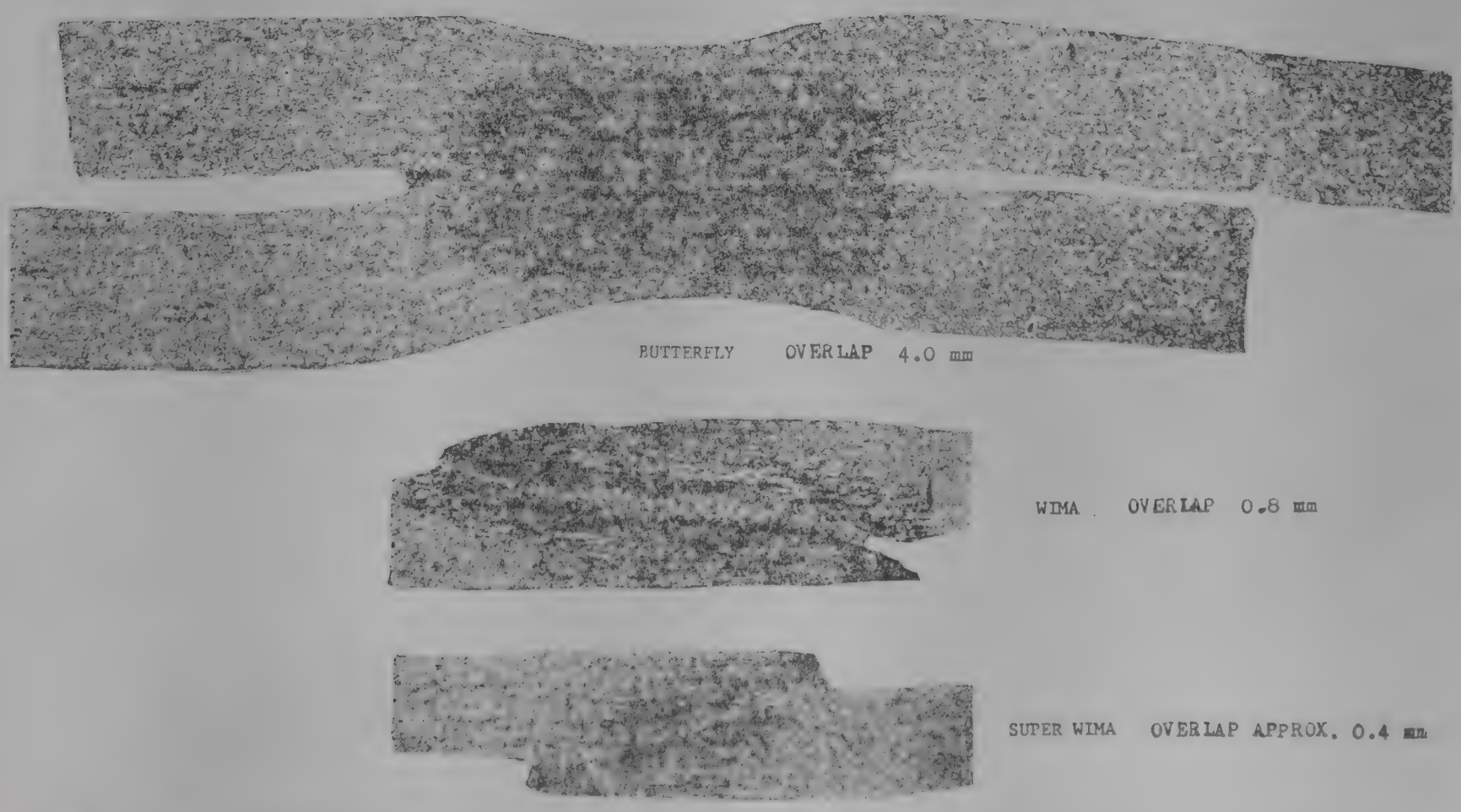


Fig. 2. Typical transverse sections through a normal burterfly weld, wima weld and super wima weld (×100)

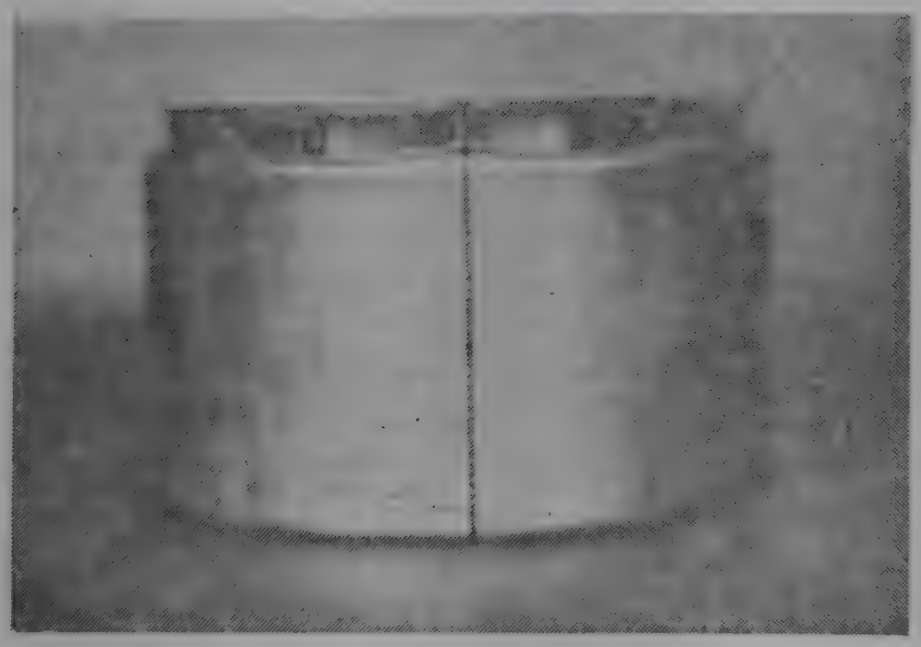
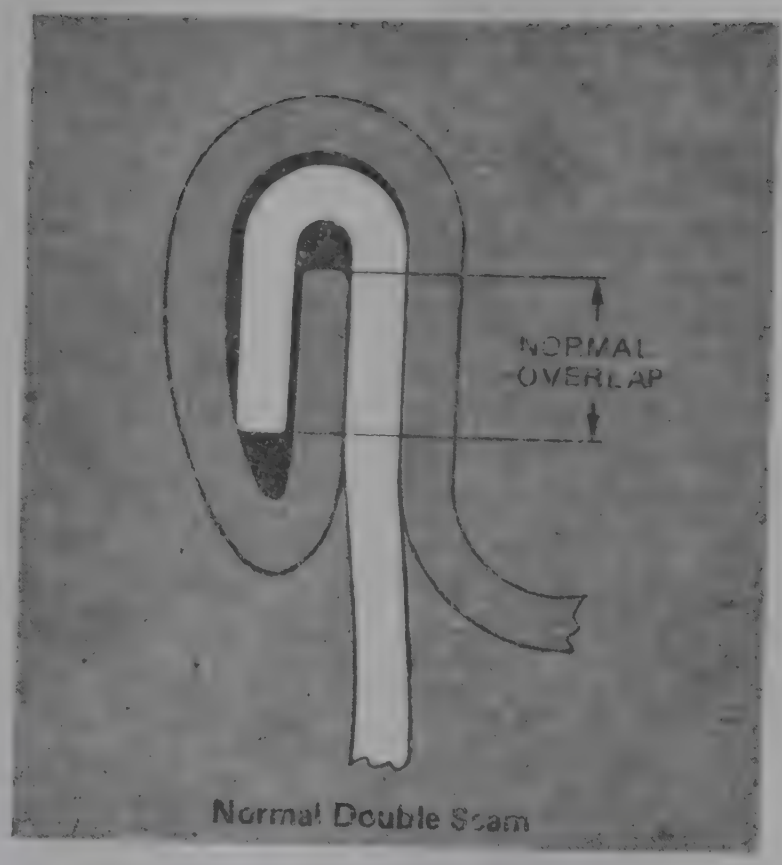


Fig. 3. Reverse Flanged can.



Advantages of Welded Can Over Soldered Can:

Free From Lead:

The normal solder used on soldered cans is made of tin and lead and traces of this lead can go into the food. The limits of lead pick up in canned food is getting tighter and tighter with some countries demanding zero level. The welded can is free from lead. Some doubt is cast on whether copper from electrode wire is deposited on the weld and thus go into canned product but in fact the tin gets deposited on the copper wire. We have not detected any copper in the cans that we have pack tested.

Pure tin could be used as a lead free solder, but it is not very economical.

Improved Performance:

I have mentioned that the Superwima seam is about 1.3 times thicker than the plate thickness. This ensures easier double seaming at side seam/ double seam juncture. This and the improved integrity of the welded side seam is expected to give lower leaker/spoilage rates in welded cans as compared to soldered cans. The soldered can has two thicknesses of plate at the lap of the side seam plus the thickness of the solder. This extra metal can produce droop in the cover hook juncture and hence possibilities of leaker/spoilage (Fig. 4).

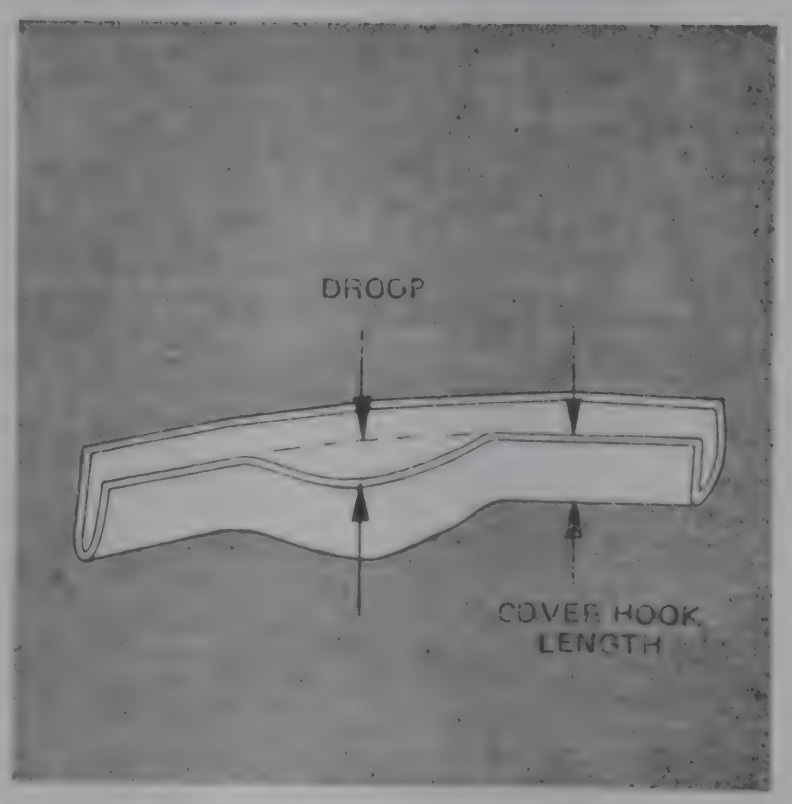


Fig. 4. Double seam section and droop in cover hook

Material Saving:

Superwima requires 0.4 mm overlap and thus needs less metal compared to soldered cans which require interlocking hooks to form a seam (Fig. 5).

Fig. 5. Sideseam Cross-section

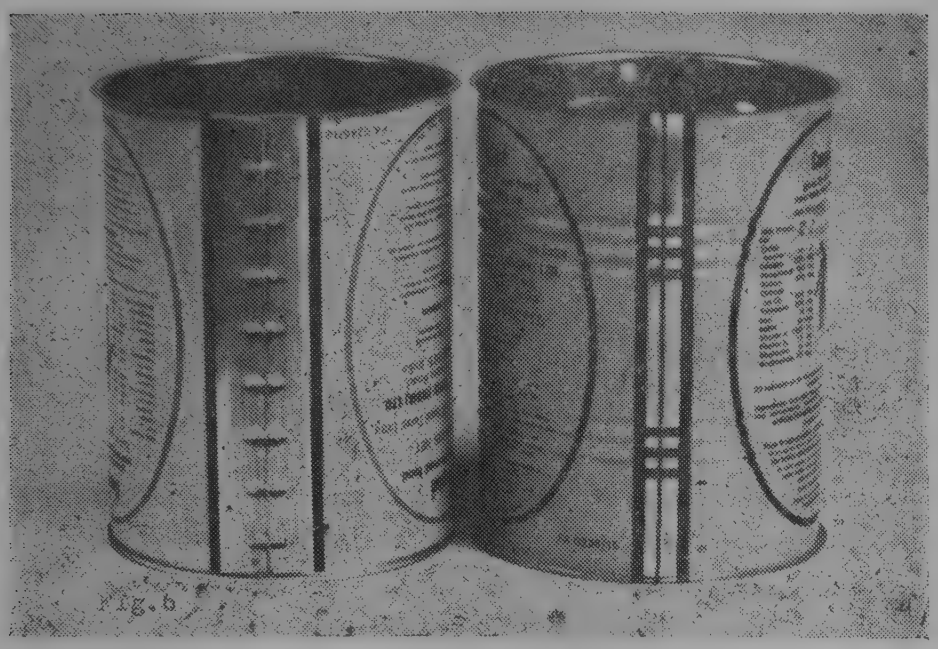


Fig. 6. Printing and decoration on welded and soldered cans.

Improved Appearance:

The decoration/printing on the welded can can be extended further towards the side seam. In soldered can this has to be cut back to prevent damage due to solder heat (Fig. 6).

Why Appropriate

The various new technologies available for metal can making are:

1. Welding
2. DWI or DI, i. e. drawn and wall ironed. Here a cup is formed first and then walls of the cup are ironed to the required height.
3. DRD—Draw & Redraw, i. e. two or three stage draw to get the final size cans.
4. IE—Impact Extruded. This is used only for aluminium cans. DWI, DRD and IE form what are called as 2 piece seamless cans as you can see in Fig. 7. IE cans can be made only in aluminium and the material saving is not as high as DWI and only used for limited market, such as packs for airlines (Fig. 7).

The major disadvantage of two piece cans is that they cannot be flattened. In India majority of the cans for processed food go to the customer as flattened bodies (Fig. 8) and loose ends, to reduce transportation costs. These bodies are subsequently reformed, flanged and seamed by the canner. The welded can allows this continuity.

DWI or DRD demand high capital expenditure and are not economical unless large volumes are produced. In the case of DRD there is no comparative material saving and certain sizes of cans are difficult to manufacture because of dia./height ratio. DWI is mainly used for small to medium size beverage cans, i. e. pressurised containers as its walls are not strong enough to withstand processing and subsequent vacuum.

The welded can requires low capital expenditure compared to other technologies and the existing pre and downline equipment can be used by the can manufacturers. So also the canner has no need to change his reforming, flanging and seaming equipments. Within a machine capacity sizes can be changed easily to make small runs of various sizes. This, in fact, is very essential in India. Most of the popular sizes of various diameters and heights can be manufactured at high speed and sent in flattened condition.

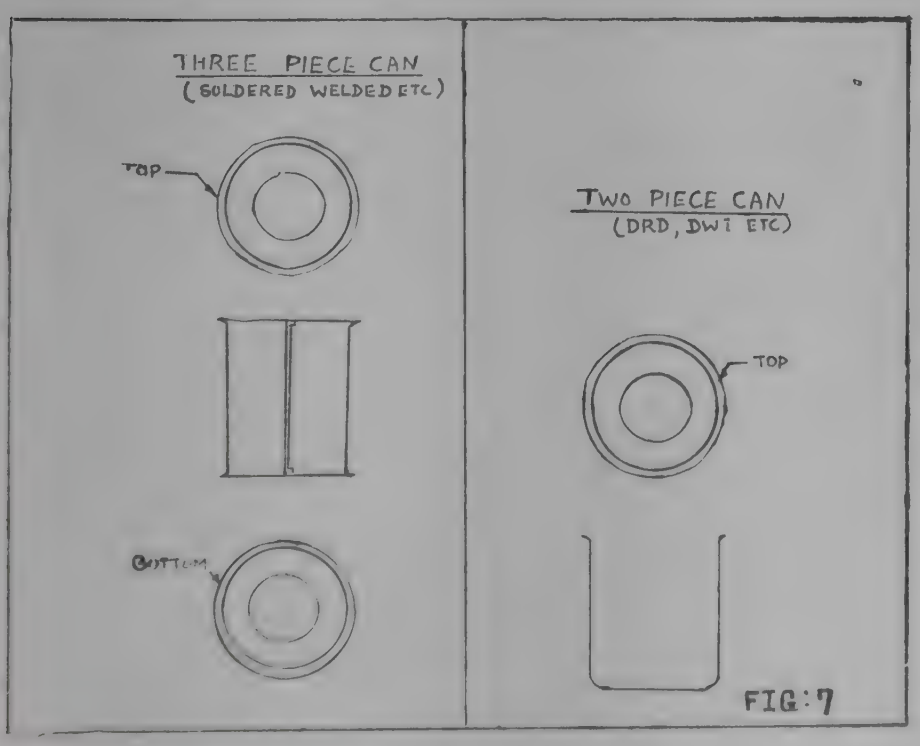


Fig. 7. 2 piece and 3 piece cans.

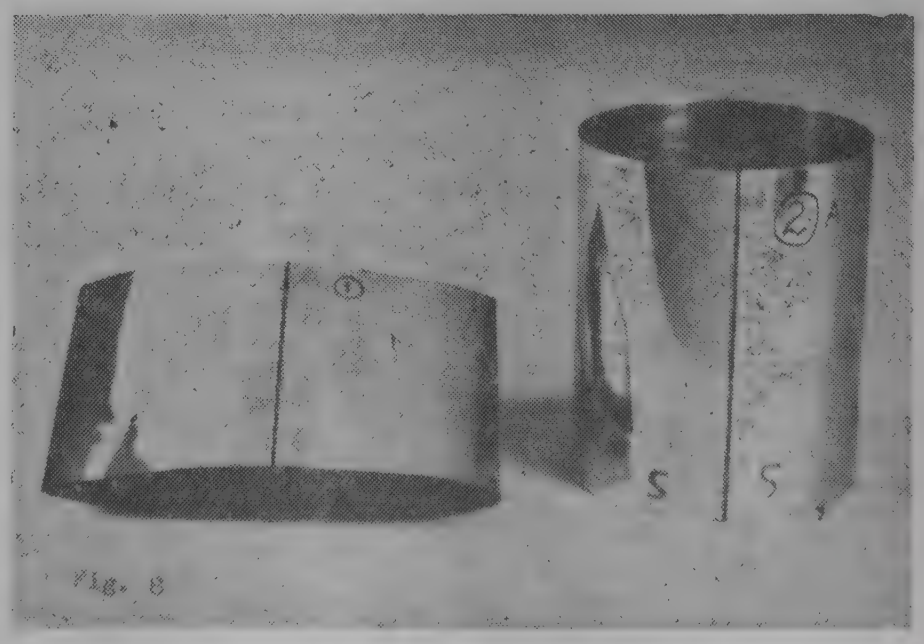


Fig. 8. Flattened can.

Can Quality:

Having said all good things about welded cans, I must also say that this technology is in certain respects more difficult for can makers, although it is expected to be easier for canners, but both have to go through a learning curve.

The quality of tinplate required will be more consistent for mechanical properties, the slitting tolerances have to be tightened up and above all the weld quality has to be carefully monitored. Can maker has to identify various weld defects and for this desctructive and non-destructive tests will be required, supported by metallurgical examination to ensure side seam integrity. For some cans the side seam may require inert gas shielding at the time of welding to prevent iron oxide growth. Some other cans may need lacquer protection by a side stripe on the seam to prevent corrosion.

Poysha Industrial Co., Bombay has carried out packing tests with mango juice and potatoes in Superwima welded cans jointly with CFTRI. The results have been extremely satisfactory. Tests with other products are in progress.

Conclusion:

By now, continuously renewed copper wire electrode welding has become almost universally used process for food and beverage can manufacture. The use of welded cans for processed food and beverage cans has grown rapidly and welded cans have replaced soldered tinplate cans steadily. We have seen how in many ways this technology is suitable to us in India. It is up to us to make the best use of it.

Suitability of Selected Packaging Materials to store A Spray-Dried Acidophilus — Malt Preparation

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ABSTRACT

Spray dried acidophilus—malt containing about 10 million live **Lactobacillus acidophilus** *per gram was prepared and its storage stability in different flexible packaging materials viz. (i) Polyethylene lined aluminium foil (ii) Polyethylene and (iii) metal coated polypaper was assessed. During the storage the moisture content increased and the lactobacillus count decreased at different rates depending on the type of the packaging material. The final per cent moisture was 3.12, 3.61 and 6.59 and the per cent survivors were 9.13, 4.39 and 2.14 for the packaging materials (i), (ii) and (iii) respectively. From the above findings polyethylene lined aluminium foil bags could be suggested as one of the suitable packaging materials for dried products containing live lactobacillus cells. Polythylene bags were ranked second best and the cheapest among the three.*

The group 'lactic acid bacteria' comprises Gram positive, asporogenous, catalase negative, microaerophilic to anaerobic rods (genus Lactobacillus) and cocci (genera Streptococcus, Leuconostoc, Pediococcus and Peptostreptococcus) whose end product is mainly or exclusively lactic acid. Some numbers of the genus Lactobacillus are indigenous to the intestinal tract of men and animals. Their residence in the intestine is believed to help establish and stabilize the intestinal microflora of healthy individuals. "Acidophilus therapy" is now getting wider recognition as cure for gastrointestinal disorders/infections by various aetiological agents. Because of these outstanding benefits, several species of lactobacillus, particularly *Lactobacillus acidophilus,* are used in preparation of a number of microbiotic feed supplements and dietary adjuncts[1].

Traditionally, acidophilus milk was prepared from severely heat treated milk, inoculated with *L. acidophilus* and incubated at 37°C for about 24 h. Despite the well documented health benefits the flat and sour taste of the product did not appeal much to the consumers and this led to development of many products containing *L. acidophilus* in different forms and attractive palates *viz.* sweet acidophilus milk, acidophilus yoghurts, acidophilus yeast milk, acidophilus paste and concentrates, acidophilin, acidophilus ice-cream and acidophilus pudding[2-4]. The newer acidophilus products did improve the palatability and consumers acceptance but still had problems of high cost, and limited storageability even at refrigerated temperatures with regard to viability of the cells and other possible jeopardizing changes.

Various modes of drying are widely employed for commercial manufacture of dried-foods. A few attempts have been made to spray-dry or freeze-dry the milk containing *L. acidophilus* cells [5-12]. The advantages of extended storageability, transportation, marketing and consumers' convenience in dried products are attractive attributes[9-11].

Milk, egg and fish are superior quality proteins in comparison to cereal proteins[13-14]. If cereal proteins are supplemented with milk proteins the protein quality of the resultant blend could be elevated due to supplementary effect of milk proteins[15-19]. In the present study, along with *L. acidophilus* in dried form, it was also considered desirable to replace as much milk solids as possible with cheaper cereal solids. Thus a new product containing large number of live *L. acidophilus* cells in a spray-dried powder form *viz.* spray-dried acidophilus-malt preparation was formulated. To select proper packaging material, three different flexible types of packaging materials were used and the atmospheric storageability of the product upto two months was studied with respect to

changes in moisture content and viable lactobacillus count.

Materials and Methods:

Three different types of flexible packaging materials viz. (*i*) polyethylene lined aluminium foil having 10.2 μm thickness supplied by M/s. Vicks (India) Pvt. Ltd., Bombay; (*ii*) polyethylene bags having 12.8 μm thickness purchased from the local market and (*iii*) metal coated polypaper bags having 8.9 μm thickness of Titaghur Paper Mills Ltd. Co., Bombay were selected for the study. The thickness was measured with dial thickness gauge (Mitutoyo Co. Pvt. Ltd., Japan). About 20 g product was filled in the bags having dimensions 150×100 mm (L×W) and the bags were heat and pressure sealed with DGS (India) make electric sealer.

The sealed bags were stored at ambient temperature and humidity for two months. Every tenth day during two months storage two bags from each type of packaging material were examined for changes in lactobacillus count and moisture content. The moisture content was determined by gravimetric method[20]. For lactobacillus count, eleven grams sample of the powder was weighed aseptically in a 50 ml sterilized beaker and the contents were transferred aseptically to 99 ml phosphate buffer, pre-warmed to 45°C and the contents were mixed throughly[21]. Further dilutions were made and one ml from suitable dilution was put into sterile petridishes in duplicate, 10-15 ml of sterilized molten MRS agar[22] was poured and the plates were allowed to solidify. The second layer with uninoculated agar was put to create partial anaerobic conditions to favour the growth of *L. acidophilus.* The plates were incubated at 37°C and at the end of 48-72 h incubation period the colony forming units (c.f.u.) of lactobacillus per gram was calculated.

Experimental data were subjected to statistical analysis to decide the relative merits of the tested packaging materials.[23]

Results and Discussion

The flow diagram to prepare the product and its Physico-chemical composition is given in Fig. 1 and Table 1 respectively.

Changes in moisture content of the product during storage packed in three different types of flexible packaging materials are shown in Table 2. Observations revealed that there was rise in moisture content of the product packed in all the three types of flexible packaging materials during the entire period of the storage but at different rates. The highest rise in moisture was in the metal coated

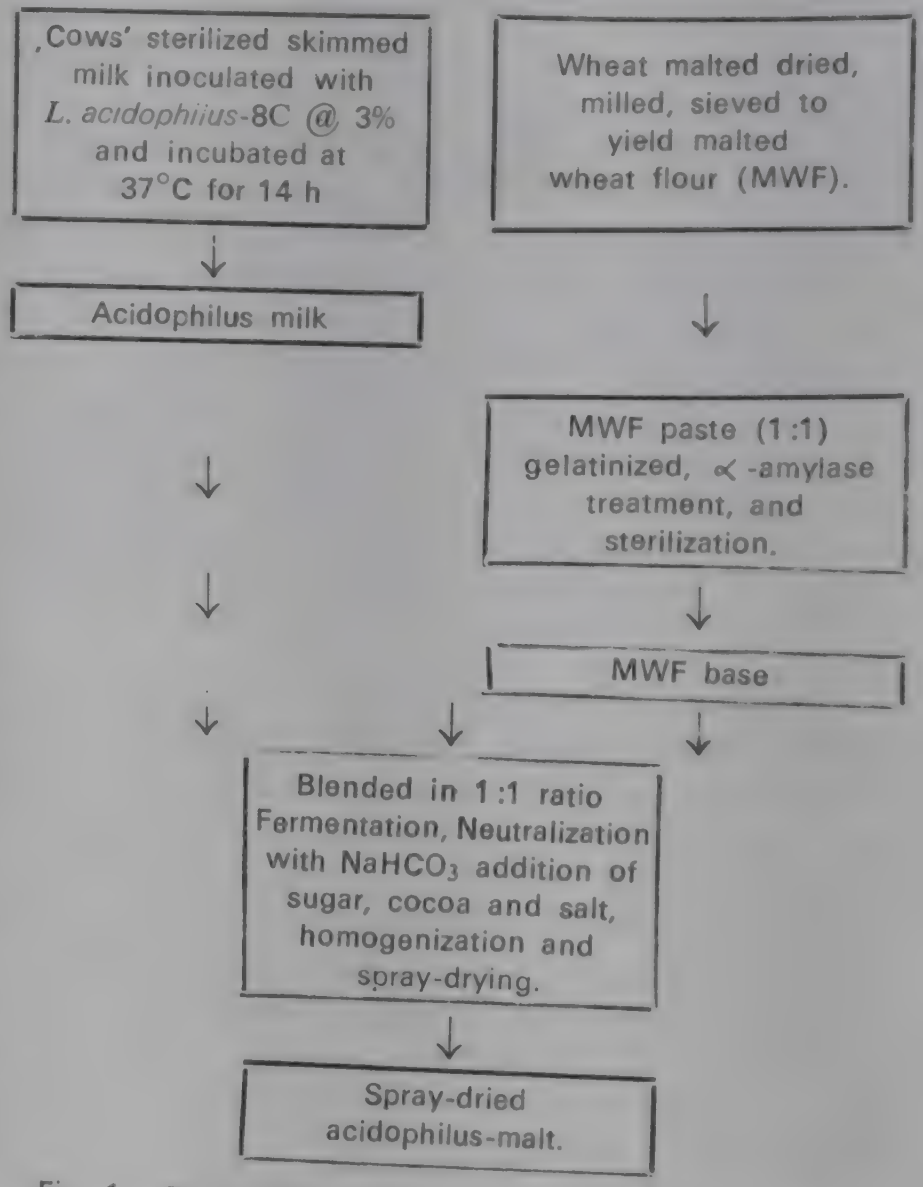
'Cows' sterilized skimmed milk inoculated with L. acidophilus-8C @ 3% and incubated at 37°C for 14 h
Acidophilus milk
Wheat malted dried, milled, sieved to yield malted wheat flour (MWF).
MWF paste (1:1) gelatinized, ∝-amylase treatment, and sterilization.
MWF base
Blended in 1:1 ratio Fermentation, Neutralization with NaHCO3 addition of sugar, cocoa and salt, homogenization and spray-drying.
Spray-dried acidophilus-malt.

Fig. 1. Flow diagram for preparation of the product-spray dried acidophilus-malt.

Table 1. Physico-chemical analysis of spray-dried,, acidophilus-malt preparation

Chemical attributes	
Moisture	— 2.66% (w/w)
Total protein (% N×6.25)	— 17.0 % (w/w)
Fat	— 2.09% (w/w)
Ash	— 3.04% (w/w)
Carbohydrates	— 75.21% (w/w)
Niacin	— 30.61 μg/g
Riboflavin	— 18.77 μg/g
Starch test	— Negative
Physical attributes	
Solubility index (ml)	— 3.3
Bulk density (g/ml)	
Loose	— 0.29
Packed	— 0.39

Table 2. Changes in moisture content of spray-dried acidophilus malt preparation packed in different packaging materials during storage

Packaging material	Per cent Moisture Storage Period (in days)						
	0	10	20	30	40	50	60
Metal Coated Polypaper bags	2.68	3.74	4.80	5.93	6.31	6.44	5.59
Polyethylene lined aluminium foil bags	2.68	2.91	2.98	3.01	3.03	3.05	3.12
Polyethylene bags	2.68	2.89	3.15	3.26	3.40	3.49	3.61

Table 3. Changes in lactobacillus count (log values) in spray-dried acidophilus-malt preparation packed in different packaging materials during storage

Packaging material	Log Viable Count (Per gram) Storage Period (in days)						
	0	10	20	30	40	50	60
Metal coated polypaper bags	6.99	6.66	6.35	5.91	5.53	5.50	5.33
Polyethylene lined aluminium foil bags	6.99	6.92	6.61	6.27	6.06	5.93	5.81
Polyethylene bags	6.99	6.64	6.19	6.05	5.93	5.67	5.64

poly-paper bags which was from initial 2.68 to final 6.59 per cent moisture. In the polyethylene bags the increase in moisture was upto 3.61 from initial 2.68 per cent. The least rise in moisture content was observed with polyethylene lined aluminium foil bags from 2.68 to 3.12 per cent.

Statistical analysis revealed that among the three packaging materials selected for the study the polythylene lined aluminium foil was the best. Polyethylene was found to be at par with polyethylene lined aluminium foil. Metal coated polypaper was ranked the last.

The final moisture in all the three types of packaging materials was significantly higher than that of the initial moisture content.

During storage of the product in polyethylene lined aluminium foil bags upto fifty days of storage there was no significant rise in the moisture content as compared with the initial moisture content.

During the storage of the product in polyethylene bags no significant rise in moisture was found at ten days of storage period. However, it was significantly higher at the end of twenty days of storage as compared with the initial moisture content. Between twenty and fifty days of storage the increase was non-significant.

During the storage of the product in metal coated polypaper bags significant increase in moisture content was found upto thirty days of storage in comparison to initial moisture level. The subsequent increase from forty days till the end of storage period was non-significant. It was also observed that the product packed in these bags showed caking behaviour after thirty days of storage period due to penetration and absorption of moisture.

The observations contained in Table 3 show the changes in viable lactobacillus count during storage of the product in the three different flexible packaging materials. Results showed that the viable lactobacillus count decreased constantly in all the three types of packaging materials along the entire period of storage.

The viable lactobacillus count of the product packed in the polyethylene lined aluminium foil at the end of the two months storage was decreased from initial 9.95×10^6 c.f.u/g to 9.08×10^5 c.f.u./g giving 9.13% survivors, while the count for the Polyethylene and metal coated Poly Paper packed products were decreased to 4.37×10^5 c.f.u./g and 2.14×10^5 c.f.u./g respectively.

Statistical analysis revealed that all the three types of packaging materials were significantly different from each other. Among the three, polyethylene lined aluminium foil was the best as packaging material followed by polyethylene and metal coated polypaper.

The product packed in polyethylene lined aluminium foil bags showed significant decline in count over the two months storage period. During

the storage of the product no significant decline in viable count was observed upto ten days. The count thereafter decreased significantly upto forty days of storage. The decrease in counts between forty to fifty and fifty to sixty days of storage was not significant.

Polythylene bags used as a packaging material for storage of the product showed significant decrease in the number of viable cells at the end of two months storage. During the storage, significant decline in viable count was observed upto twenty days. The decline in number recorded during the storage periods of twenty to thirty, thirty to forty and fifty to sixty days was not significant.

Storage of the product in metal coated polypaper bags also showed significant reduction in count at the end of two months storage in comparison to initial count. During the storage, significant reduction in viable cells was observed upto forty days. However, during forty to fifty and fifty to sixty days of storage non-significant change in viable count was observed.

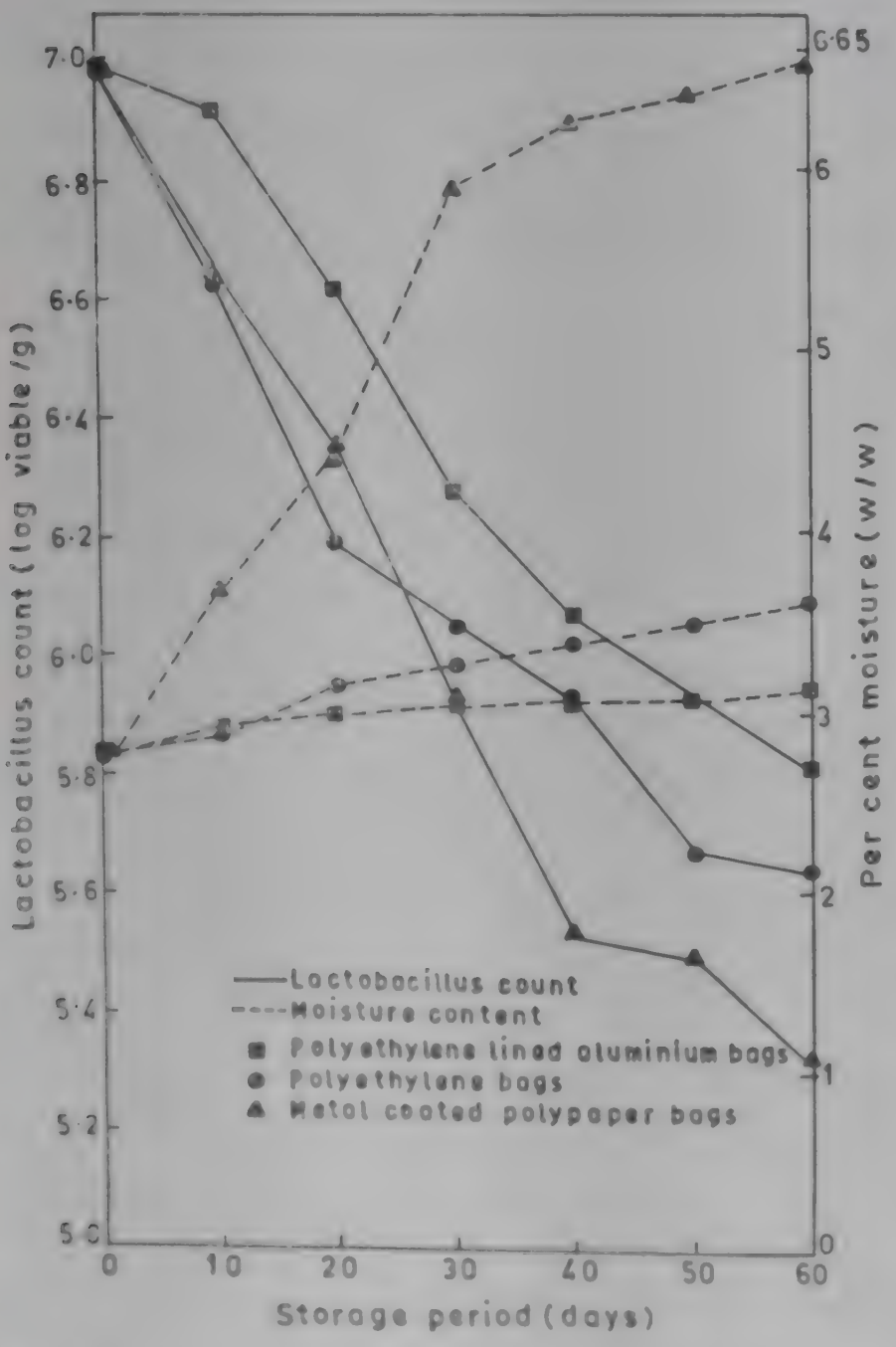

Fig. 2. Changes in Moisture content and Lactobacillus count in Spray-Dried Acidophilus Malt preparation During storage in different packaging Materials

Effect of moisture on lactobacillus count can be seen on Fig. 2. The increase in moisture content and the decline in lactobacillus count seemed to have some relationship. The highest survival was observed in the product packed in Polyethylene lined aluminium foil bags where the increase in moisture content was lowest compared to products packed either in Polyethylene or metal coated polypaper bags. Rate of permeation into a package depends on the water-vapour pressure in the atmosphere, temperature, size of the packaging material and the manufacturing process which may form a surface layer with different characteristic interior to the film or package.[24-25]

The report of Kalugin[26] on kinetics of moisture absorption by freeze-dried yoghurt and acidophilus paste in powder and briquette forms stored at 22±2°C and 30-80 per cent relative humidity says that a constant moisture content is achieved within 15-16 days in the powdered products and 35-40 days in briquettes. The results of the present study are in conformity with the above literature data.

The present investigation reveals that the product could be stored at atmospheric temperatures suitably in polyethylene lined aluminium foil bags or high density polyethylene bags with large number of live *Lactobacillus acidophilus* cells surviving even after one to two months storage. The results also led to the inference that the type of the packaging material selected for a product containing live cells and desired to maintain them in live condition, should be impervious not only to the moisture but probably also to gases including atmospheric oxygen.

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Functional Efficiency of Newer Packaging Materials with Reference to Insect Free Packaging

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ABSTRACT

The packaging industry has introduced a number of films and laminates keeping in view the needs of the food industry. Studies were carried out on the protection given by these films against insect pests of raw and processed foods. Aluminium foils, polyester polyethylene, metalised polyester and higher gauges of polyethylene, and polypropylene which have better functional properties gave protection for considerable length of time, which again was related to the type of insects and the density of the population. Films and laminates based on aluminium, polyester and cellulose resisted permeability of fumigants which is an important factor in the control of endemic infestation. The minimum and maximum percent fumigant permeated was, MB 6 (Glassine)-31 (HDPE), EDB 0(Paper-LDPE-Al. foil)-40 (HDPE), MF 4 (Paper LDPE Al. foil)-50 (glassine), PH^3 0(HDPE), polypropylene, Met-polyester, polyester polyethylene, Al. foil, Paper-Al. foil-polyethylene)—16 (100G HDPE).

Agricultural commodities are processed into different products for essential consumption, convenience, for flavour, taste and texture. The products are packed and stored in sacks of jute, textile fabrics, lined for laminated fabrics and in flexible plastic containers to preserve their quality attributes till consumption. The constituent characteristics of products play an important role in deciding about the type of packaging materials that needs to be used. The deteriorative changes that occur depend on the chemical composition of the packed products and the environmental conditions to which they are subjected during transportation and distribution. Among the external factors which influence package selection are the atmospheric temperature and relative humidity, oxygen, partial pressure difference[2] and physical factors like abrasion, external pressure or compression and biological factors like rodents, insects and microorganisms.

Amongst the biological factors, the insect pests of raw and processed foods are very important. A random survey of the infested packaged food products has revealed that *Sitophilus oryzae* (L), *Rhizopertha dominica* (F), *Tribolium castaneum* (F), *Oryzaephilus surinamensis* (L) and *Stegobium panicium* (L) constituted the major insect population. Most often the agricultural commodities, unless they are specially processed, carry infestation in the latent forms before they are packed. They may be destroyed during processing. But the infestation of the processed foods would be invariably different from that of the whole material. Further, in the time lag between processing and packing, insects might get access into the product. Also insect infestation may occur on the grocers' shelf. Insect infestation results in a total loss of the products and also affects other physico-chemical properties of the packaging materials. There are few reports on the insect resistance of packaging materialis[1, 2, 3, 5, 6, 7, 8, 11, 12] and on the permeability of fumigants through some films.[13, 14, 15]

The selection of packaging material and package forms is dictated by the type of protection required, the cost of the product, the shelf life sought and finally the availability of a suitable packaging material and converting equipment. For this reason, the various physico-chemical properties including the resistance to insect penetration and fumigant permeability of few newer packaging films introduced by the industries were evaluated.

Materials and Methods

1. Physico-Chemical Tests: For conducting the various physico-chemical tests, the specifications as indicated in an earlier study[10] were employed.

2. Test Insects: The following test insects of recommended age groups were tested to carry out the resistance studies. *Tribolium castaneum, Sitophilus oryzae, Rhizopertha dominica* and *Stegobium panicium.*

3. Fumigants: Methyl bromide (32 mg/L), Ethylene dibromide (32 mg/L) Methyl formate (32 mg/L) Ethyl formate (44 mg/1), Phosphine (1.5 mg/L) were tested for their permeability through the packaging materials.

4. Packaging Materials: The packaging materials tested were the following:

LDPE 200 Gauge
LDPE 400 G (G=gauge)
HDPE 100 G
HDPE 200 G
Polypropylene 200 G
Polypropylene 300 G
MXXT cellophane 300
MXXDT cello/LDPE 150 G
Polyester 12 μm G/LDPE 300 G
Met. Polyester 12 μm G/LDPE 150 G
Polyester 12 μm G/Al. foil 0.02 mm/LDPE 150 G
Cellophane 300/Al. foil 0.02 mm/LDPE 150 G
Glassine paper.

Insect Penetration Studies

Insect penetration studies were carried out with four common types of insects using desiccators. 25×25 cm samples of the films to be tested were placed on the rim of the desiccator. The lid of the desiccator was placed on the film after removing the standard joint glass gascock. 100 adult test insects were released through the opening on to the surface of the film. In another set the test insects along with food materials were placed on the test films. Observations were made at intervals of one week to look for insect entry at the bottom of the desiccator. Insects without food was replaced once in ten days. Studies were carried out for a period of three months. Similar methods and their advantages have been discussed by earlier workers[1-2].

Fumigant Penetration/Transmission Studies

Permeability of fumigant through the films was carried out in 2.5 L capacity desiccators, provided with two one centimeter holes on the body closed with rubber septum for monitoring gas concentration in the desiccators. Vacuum grease was smeared on to the upper flat surface of the collar to hold the films. 25×25 cm film samples to be tested were cut and placed on the greased collar. The desiccator lid with open outlet was placed on the film. The total area exposed was 172 cm.^{2} Gas tightness was tested by creating negative pressure in the desiccator and observing the buckling of the film confirming the gas tightness.

Calculated quantities of gaseous fumigants were drawn from the reservoir and introduced by means of a gas tight syringe after creating a slight negative pressure in the desiccator. Liquid fumigants were introduced similarly by means of a microsyringe. The desiccators were brought back to atmospheric pressure. Atmospheric temperature during the study was in the range of 25-28°C. At the end of 1, 2, 4, 8 and 24 hrs fumigant concentrations in the desiccator was measured. Bromide and formate concentration was measured with Riken Interferometer using a recirculation device and phosphine by detector tube method of Muthu *et al.*[16] Gas concentrations were plotted against time to arrive at the CT (concentration×time) product mean concentration and transmission rate. One blank run was made using a glass sheet in place of film to discount the adsorption by the desiccator wall surface. Studies were carried out in triplicate.

Results and Discussion

Physico-Chemical Properties:

The physico-chemical properties of the tested packaging materials is given in the table 1. HDPE film had higher tensile and bursting strength than LDPE and better barrier properties with respect to water vapour and oxygen transmission. Cast polypropylene had values midway between LDPE and HDPE. Polyester based laminates had high tensile and bursting strength due to polyester web. The high tearing resistance in the polyester/polyethylene laminates could be attributed to polyethylene layer. This high protective physical properties coupled with smooth surface of the outer polyester film may be responsible for resistance to insect penetration. This phenomena has been reported by some workers[3, 4]. The cast polypropylene has high tensile strength. The transmission to water vapour of any material is of special significance in food packaging as most of the quality attributes of a food depends on its moisture content. It is interesting to note that metalisation of hydrophilic polyester reduces water vapour transmission (WTR) rate considerably. Even a laminate of polyester/75 micron LDPE had a high

Table 1. Physico Chemical Properties of Flexible Packaging Materials

Sl. No.	Packaging materials	Tensile Strength KN M		Elongation %		Bursting Strength K. pa	Tearing resistance g		W.V.T.P. 0.25 μ m	O_2T.R. cc 0.25 μ m
		M.D.	T.D.	M.D.	T.D.		M.D.	T.D.	m^2 24 hrs 38°C, 90%RH uncreased	m^2, 24 hrs. atmospheric, 25°C
1.	LDPE 200 G (5 μm)	1.18	0.59	High	High	117.7	120	>120	8.2	3100
2.	HDPE 200 G (gauge)	1.19	1.05	500	500	137.7	270	360	2.5	1450
3.	Cast PP 200 G	1.31	1.25	300	350	196.1	132	180	4.5	1700
4.	OPP 200 G	2.2	2.0	70	70	—	10	10	2.0	1240
5.	MXXT Cello 300 gsm	2.62	1.28	25	35	235.3	33	40	8.5	45
6.	Glassine 40 gsm	2.55	1.43	5	5	117.7	48	83	1920	High
7.	PET 50 G	1.83	1.37	22	20	313.8	12	12	39.6	160
8.	PET 50 G/LDPE 300 G	3.30	2.53	100	65	313.8	165	180	4.9	75
9.	MET PET 50 G/LDPE 150 G	2.97	2.67	82	70	516.8	105	123	0.5	1
10.	MXXT Cello 300/LDPE 150 G	3.14	1.43	30	75	274.6	120	128	6.4	6
11.	MSADT Cello 50 G/Foil 80G	4.39	2.73	35	50	551.1	134	168	<0.02	—
12.	PET 50 G/Foil 80G/ LDPE 150G	4.30	3.56	90	60	509.9	177	228	0	—
13.	Paper 60 gsm/LDPE 80 G Al. Foil 80 G/LDPE 150 G	3.86	3.24	40	50	274.6	165	189	0	—
14.	Paper 60 g/LDPE 80 G/ Al. Foil 80 G/LDPE 150 G	3.86	3.20	50	60	274.5	168	186	0	—

value of 4.9 and that of metallised polyester/37.5 micron LDPE had a value only 0.5 g/m^2d. This indicates that metallised structures have low WTR values although they are not as effective as Aluminium foil combinations which had less than 0.02 g or even nil rates. As regards Oxygen transmission rates also, similar trends were observed.

Insect Resistance of packaging materials

The results of the insect resistance trials of flexible packaging materials to the stored product insect pests are depicted in Table 2. The studies revealed that *Sitophilus* and *Rhizopertha* chewed through the films LDPE upto 400 G, HDPE upto 200 G, MXXT cellophane and MXXDT cellophane/LDPE, while they failed to penetrate/chew through other films over a period of three months. While *Tribolium* could get through 200 G LDPE at the end of 3 months, *Stegobium* could not chew through any of the test films under the test conditions. However, studies carried out over long periods (7 months) along with infested stocks, have revealed that *Stegobium* could chew through lower gauges of LDPE, HDPE and metallised polyester pouches containing spice mixes. The study also revealed that the insect requires a foot hold/anchorage to chew through/ penetrate the packaging materials. Similar trend has been observed by otherworkers[6, 8] where at ambient conditions of storage, it was observed that common insects failed to penetrate paper/Al. foil/ polyethylene laminates and 75 micron HDPE film. However, the foil laminates which have resisted insect penetration are not absolute barriers.[5-6] It is probable that as an outer layer, smooth and high physical strength polyester could be more effective in restricting the entry of insects than paper which has a rough surface and usually used as the outermost layer of laminated materials.

The variation of insect penetration by particular insects over periods may be due to the weakening of the film due to constant scouring action of insects. Another observation made by this study was the

Table 2. Insect Resistance of some Films and Laminates

Temp. 25-28°C
R.H. 70-75%

Films	1 Week				1 month				2 months				3 months			
	S	R	St	T	S	R	St	T	S	R	St	T	S	R	St	T
LDPE 200 G (gauge)	—	—	—	—	+	+	—	—	+	+	—	—	+	+	—	+
LDPE 400 G	—	—	—	—	—	—	—	—	+	+	—	—	+	+	—	—
HDPE 100 G	+	—	—	—	+	—	—	—	+	+	—	—	+	+	—	—
HDPE 200 G	—	—	—	—	—	—	—	—	+	+	—	—	+	+	—	—
HDPE 300 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polypropylene 200 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Polypropylene 300 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
300 MXXT Cellophane	+	—	—	—	+	+	—	—	+	+	—	—	+	+	—	—
300 MXXDT Cello LDPE 150 G	—	—	—	—	+	—	—	—	+	+	—	—	+	+	—	—
PET 50 G/LDPE 300 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
MET-PET 50 G/LDPE 150 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
PET 50 G/Al. Foil 0.02mm/LDPE 150 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
300 Cello/Al. Foil 0.02mm/LDPE 150 G	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

S=*Sitophilus oryzae* St=*Stegobium panicium* PET=Polyester

R=*Rhizopertha dominica* T=*Tribolium castaneum* MET=Metallised

requirement of a foot-hold for the insects to pierce/chew through. This was noticed by the insect holds observed along the edges of the desiccator collar only when insects alone were released while with food materials on the film resulted in insect exit holes on the body of the films, wherever the film was found susceptible.

Permeability of fumigants through films:

The results of the permeability of fumigants through films is presented in table 3. The Table gives the mean concentration, percent fumigant permeated and the rate of transmission.

Methyl bromide: The percentage of methyl bromide permeated through the test films was in the range of 6-31% in 24 hours with a dosage of 32 mg/L. The maximum permeability was with HDPE and polypropylene. Polypropylene was equal in its performance to that of HDPE of similar gauges. The least was with MXXDT cellophane followed by glassine paper. The transmission rate of MD through test films was in the range of 4-9 mg/m^2/hr.

Ethylene dibromide: With a dosage of 32 mg/L the permeability through the film was in the range of 0-35% in 24 hours. Maximum was in HDPE (100 G) and least in metallised polyester polyethylene. The transmission rate was in the rage of 0-63 mg/m^2/hr.

Ethyl formate: With a dosage of 44 mg/L the permeability through the films was in the range of 10-47% in 24 hours. The maximum transmission was in polyester polyethylene and least in the paper/LDPE/Aluminium foil/LDPE. HDPE and Polypropylene fared better than polyester polyethylene. The transmission rate was in the range of 18-84 mg/m^2/hour.

Methyl formate: With a dosage of 32 mg/L the permeability through the film was in the range of 4.7-50% in 24 hours, the least in the paper/aluminium foil/LDPE and maximum in glassine paper. The transmission rate was 11-120 mg/m^2/hour.

Phosphine: The permeability of phosphine through the film with a dosage of 1.5 mg/L, was

Table 3. Permeability of Fumigants Through Films and Laminates

Temp. 25-28°C
R.H. 70-75%

Sl. No.	Films	Methyl bromide 32 mg/L			Ethylene dibromide 32 mg/L			Methyl formate 32 mg/L			Ethyl Formate 44 mg/L			Phosphine 1.5 mg/L		
		MC	P%	PR	MC	P%	PR	MC	P%	PR	MC	P%	PR	MC	P%	PR
1.	HDPE 100 G (gauge)	14.7	31.0	42.0	11.2	35.0	63.0	20.7	47.0	113.0	12.4	40.5	72.9	0.24	16.0	1.3
2.	HDPE 200 G	14.5	30.0	41.0	9.3	28.5	51.0	6.5	20.5	50.1	5.8	24.0	43.2	0.0	0.0	0.0
3.	HDPE 300 G	12.9	23.3	29.0	6.1	18.8	34.0	6.0	15.0	36.4	7.0	21.2	36.4	0.0	0.0	0.0
4.	Polypropylene 200G	14.5	30.0	41.0	9.2	28.5	31.0	7.4	17.0	41.0	8.7	29.1	52.4	0.05	3.2	0.26
5.	Polypropylene 300G	11.6	18.0	25.0	9.2	28.5	31.0	3.0	7.2	17.3	7.0	24.0	43.2	0.0	0.0	0.0
6.	300 MXXT Cello	12.7	22.3	31.0	9.0	27.9	49.0	20.7	47.1	113.9	2.9	26.5	47.8	0.25	16.6	1.3
7.	300 MXXDT Cello LDPE 150G	8.7	6.4	9.0	8.0	25.9	46.0	25.7	25.4	61.5	13.9	44.3	79.6	0.14	8.8	0.72
8.	PET 50 G/LDPE 300G	11.4	17.5	24.0	4.2	30.0	23.0	18.6	42.4	102.5	14.5	46.8	84.3	0.5	3.2	0.26
9.	Met PET 50G/LDPE 150G	12.2	20.8	28.0	0.0	0.0	0.0	13.2	30.1	72.9	7.9	26.5	47.8	0.0	0.0	0.0
10.	PET 50 G/Al. Foil 0.02 mm/ LDPE 150G	10.4	13.2	18.0	7.3	20.7	40.0	17.8	40.5	78.0	8.3	27.8	50.1	0.0	0.0	0.0
11.	Paper 60g/Al. Foil 0.02 mm/ LDPE 150G	12.4	26.1	29.0	5.9	18.8	32.0	5.7	13.2	31.9	5.4	19.0	34.1	0.0	0.0	0.0
12.	Paper 60g/LDPE 80G/0.02 mm Al. Foil/LDPE 150G	5.0	15.3	27.0	5.5	16.2	28.0	2.0	4.7	11.3	2.5	10.1	18.2	0.0	0.0	0.0
13.	Glassine 40 gsm	8.7	6.6	9.0	6.4	20.0	23.0	22.0	50.0	120.7	8.3	27.8	50.1	0.05	3.2	0.26

P =% transmission/permeation through the films

PR=Transmission or permeability rate through the films : mg hrs/m^2

MC =Mean concentration : mg/L.

in the range of 0-16% in 24 hours. The maximum permeability was with HDPE (100 G) MXXDT and MXXT cellophane and least through polypropylene (200 G), polyester polyethylene. Six out of the thirteen films tested resisted permeation of phosphine through them at the test dosage and conditions. The transmission rate was 0-1.3 mg/m^2/hour.

Conclusion

Polyester and Aluminium foil substrates had high tensile strength and resisted insect penetration. Metallisation reduced the permeability to water vapour, oxygen and fumigants. Amongst the polyolefin materials, polypropylene had highest protective properties and HDPE best barrier properties.

Sitophilus and *Rizopertha* chewed through the packaging materials, LDPE upto 400 G, HDPE 100 G and cellophanes. The latter species required a foothold for penetration. *Stegobium* and *Tribolium* could not penetrate the packaging materials under test when exposed for short periods.

The permeability of fumigants varied with the type of films. Cellulose and Aluminium backed films resisted most of the test fumigants followed by polyester backed films. Both the polypropylenes and HDPE behaved similar for permeability to fumigants. The organic fumigants permeated better than the inorganic one. The permeability of phosphine through the test films was very poor indicating caution in its use as an in-package fumigant.

Since insect infestation in processed and packed foods is very common, disinfestation is an important input for the maintenance of the quality till it is consumed. The products have to be disinfested either before packing or soon after packing since any latent forms multiply faster under packed condition. If the fumigation is to be carried out, after packing, right type of fumigant, its dosage and

exposure period is very important in view of the resistance of packaging materials for fumigant permeability.

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Effect of Polymeric Cling Film Wraps on the Storage Behaviour and Sensory quality of Apples and Oranges During Storage under Refrigerated and Ambient Conditions

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ABSTRACT

A polyethylene cling film of 15 microns was assessed for its suitability to wrap fresh apples and oranges to control transpirational losses. Studies carried out at refrigerated and ambient conditions have indicated that cling film could effectively reduce PLW as compared to wax emulsion coating.

Introduction

Commercially important fruits like apples and oranges which have to be transported over a long distance from the place of production to the different consuming centres suffer enormous loss during transportation and further storage during marketing. The losses are either pathological caused by penicillium sp, and *Diplodia natalensis* or/and physiological due to transpiration and respiration, leading to shrivelling.

Cling film, which is developed by ICI, is produced by conventional blown tubular film technique. This film having a thickness of about 15 microns has very low water vapour transmission rate (WVTR) and high gas (air) permeability. Hence, this film was assessed for its suitability in wrapping fresh apples and oranges in order to control transpirational losses during storage.

Materials and Methods

Effect of cling film on wrapping apples under refrigerated storage: Royal Delicious apples of two sizes, big and small were obtained from the local market in the month of September. The apples had arrived a week after harvest directly from Delhi by truck transport. After sorting and grading into two sizes-big and small, the fruits of each size were divided into 8 lots of 100 fruits each. Out of this, 4 lots of each size were wrapped in cling film and other 4 lots of each size were wrapped in newsprint paper as is conventionally done. All the lots were stored at 32-35 °F.

Effect of cling film and wax emulsion application on apples under refrigerated and ambient conditions: Royal delicious apples of big size were obtained from market. They were divided into 12 lots of 25 fruits each. Each of the 2 lots were given the following treatments:

1. Old wax formulation—12% concentration
2. New wax formulation No. 1 18% concentration
3. New wax formulation No. 2 18% concentration
4. New wax formulation No. 3 18% concentration
5. Wrapped in cling film
6. The other two lots were kept as control (without any treatment).

Out of the 2 lots of each treatment, one lot of each treatment was stored at *32-35*°F and the other lot of each treatment was stored at R.T.

Periodical observations were made on the percentage wastage due to fungal spoilage and shrivelling. Physiological losses in weight (PLW) was observed periodically by marking 10 fruits in each treatment and taking individual weights.

Effect of cling film and wax emulsion application on oranges during storage at ambient condition: Coorg mandarin oranges were obtained from the local market, after sorting and grading they were divided into 10 lots of 50 fruits each and were given the following treatments.

1. Treated with old wax formulation, 6, 9 and 12% concn.

2. Treated with new wax formulation of 6, 9, 12, 15 & 18% concn.
3. Wrapped in cling film
4. Control—untreated

After treatment all the fruits were kept in wooden crates and stored at ambient condition. The temperature and RH ranged between 21 and 33°C and RH 30-70% throughout the period of storage from last week of April to last week of May.

Observations were made on the physiological losses in weight by marking 10 fruits per treatment and taking initial weight, thereafter periodically weights were taken at 5 days interval over a period of 21 days. Percentage wastage due to physiological and pathological disorders were recorded. At the end of the storage period of 24 days the fruits were evaluated organoleptically by ranking technique and mean scores with the standard deviation was worked out for each quality parameter per treatment.

The air permeability and water vapour transmission rate tests were done for kraft papers treated with wax emulsions, control kraft paper and cling film.

Results and Discussion

Cumulative PLW and wastage of big size Royal Delicious apples during storage at L.T. (32-35°F) recorded in Table 1 show that at the end of the storage period of $3\frac{1}{2}$ months, fruits wrapped in cling film had a PLW of 3.3% as against 7.7% in fruits wrapped in paper. There was no wastage due to fungal attack and shrivelling upto a period of $1\frac{1}{2}$ months in both treated and untreated fruits. After a period of $2\frac{1}{2}$ months the control fruits had 11.4% wastage due to shrivelling while there was no wastage due to shrivelling among cling film wrapped fruits. Wastage due to fungal attack was 5.3% and 4.0% respectively. At the end of the storage period of $3\frac{1}{2}$ months fruits wrapped in cling film showed only 0.56% wastage due to shrivelling as against 32.6% shrivelling in control fruits. Percentage wastage due to fungal attack was almost same for both cling film wrapped and paper wrapped fruits.

The percentage wastage and cumulative percentage PLW in Royal Delicious apples of small size during storage at LT (32-35° F) show that fruits wrapped in cling film had a PLW of 4.8% at the end of the storage period of $3\frac{1}{2}$ months as against 10.2% among control fruits (fruits wrapped in newspaper). The percentage wastage due to shrivelling at the end of $3\frac{1}{2}$ months storage was 5.6% in fruits wrapped in cling film as against 39.5% among control fruits.

Cumulative percentage PLW and wastage of apples treated with different wax formulations and those wrapped in cling film and stored at ambient condition recorded in Table 2 shows that fruits wrapped in cling film had a minimum PLW of 7.6% at the end of the storage period of 65 days followed by a new formulation of wax emulsion which showed PLW of 8.2% as against 13.9% and 10.1% PLW among control fruits and fruits treated with waxol-0 respectively.

The new wax formulations reduced the WTR at 18% concentration and had almost equal air permeability of that of cling film. There was 100% shrivelling in control fruits after a storage period of 50 days at R.T. while there was no shrivelling at all among fruits wrapped in cling film and those treated with new wax formulation No. 1. Fruits treated with old wax formulation showed 50% shrivelling. The experiment was continued upto 65 days. At the end of the storage period of 65 days also there was practically no shrivelling in cling film wrapped fruits and those treated with new wax formulation.

At a storage temperature of 32-35°F also similar trend in results were obtained (Table 3), minimum PLW of 3.3% was observed in fruits wrapped in cling film. All the three new wax formulations reduced PLW more than the old wax emulsion formulation and the highest percentage PLW of 7.7% was observed among control fruits after a storage period of $3\frac{1}{2}$ months. At the end of the storage period of $3\frac{1}{2}$ months, 30% shrivelling was observed among control fruits and those treated with old wax formulation. Fruits treated with all the three new wax formulations had 10% shrivelling while fruits wrapped in cling film had no shrivelling at all. The fruits had fresh market appearance.

The data presented in table 4 indicate that at the end of the storage period of 15 days the least PLW of 5.2% was observed in oranges wrapped in cling film closely followed by fruits treated with new wax formulation (18%) while the control oranges had a PLW of 24.36%. Although all the treatments brought out a significant reduction in the PLW which ranged between 7.39% to 12.36% the behaviour of the different emulsions in the reduction

Table 1. Cumulative percentage PLW and wastage in cling film wrapped and paper wrapped Royal Delicious apples of large and small size during storage at L.T. (32-35° F)

Treatments	Period after storage (months) % PLW			% wastage											
				1½				2½				3½			
	1½	2½	3½	Good	Fungal spoi-lage	Insect	shrivell-ing	Good	Fungal spoi-lage	Insect	Shrivell-ing	Good	Fungal spoi-ing	Insect	Shrivell-ing
Large size															
Control	2.84	5.0	7.7	98.8	0.8	0.3	0	81.9	5.3	1.6	11.5	51.0	14.1	2.2	32.6
Cling film wrapped	1.05	2.2	3.3	97.5	1.0	1.3	0	94.8	4.0	1.1	0	84.4	15.0	0	0.5
Small size															
Control	3.3	6.5	10.2	97.3	0.2	2.3	2.65	67.7	4.6	6.8	20.9	34.7	18.8	12.8	39.5
Cling film wrapped	1.5	2.9	4.8	95.1	0.4	1.7	0.2	85.5	3.4	7.2	3.8	76.2	15.2	2.6	5.6

Table 2. Cumulative percentage PLW and wastage in Royal Delicious apples of big size treated with different wax compositions, wrapped in cling film during storage at R.T.

Treatments %	Period after storage									Air permeability (sec/200 ml air)	WVTR 9/m 2d @38° C & 90% RH
	% P.L.W. (days)			% wastage							
				50 days			65 days				
	35	50	65	Good	Fungal & shrivelled	Shrivelled	Good	Fungal shrivelled	Shrivelled		
Control	8.8	12.6	13.9	—	200	100	0	30	100	14.5	4141
Cling film wrapped	4.2	5.4	7.6	80	20	0	60	40	0	324	100
Old wax emulsion 12%	6.3	8.7	10.1	40	10	50	40	10	50	1680	2160
New wax emulsion No. 1 18%	5.9	7.1	8.2	90	10	0	80	20	0	330	1675
New wax emulsion No. 2 18%	6.8	9.0	10.2	80	20	0	60	20	20	309	1656
New wax emulsion No. 3 19%	6.0	7.7	9.2	60	20	20	50	20	30	2220	—

All wax emulsions are not pressure homogenized

Only control fruits which were attacked by fungus showed shrivelling.

Table 3. Cumulative percentage PLW and wastage in Royal Delicious apples of big size treated with various wax compositions and stored at 32-35°F

Treatments	Period after storage						
	% P.L.W.			% wastage			
	1½ months	2½ months	3½ months	2½ months Fungal	2½ months Shrivelling	3½ months Fungal	3½ months Shrivelling
Control	2.84	5.0	7.69	—	10	—	30
Cling film wrapped	1.05	2.20	3.3	—	0	10	0
Old wax emulsion 12%	2.96	4.88	7.07	—	0	10	30
New wax emulsion 18%	3.24	4.89	6.95	—	10	0	10
New wax emulsion No. 2 18%	3.04	5.11	6.84	—	0	0	10
New wax emulsion No. 3 18%	2.69	4.55	6.17	—	0	10	10

Table 4. Percentage PLW and wastage of variously treated oranges during storage at R.T.

Treatments		% P.L.W. Period after storage				% wastage	
		5 days	10 days	15 days	21 days	10 days	20 days
Control		11.21	19.23	24.36	29.16	—	20
Cling film wrapped		1.79	8.41	5.20		—	8
Old wax emulsion	6%	4.02	7.37	9.51		2	4
–do–	9%	4.11	6.85	9.06		6	6
–do–	12%	3.85	6.77	8.61		0	6
New Wax emulsion	6%	5.49	9.79	12.36		6	12
–do–	12%	4.28	8.00	10.30		2	8
–do–	15%	4.43	7.31	9.04		0	2
–do–	18%	3.52	5.88	7.39		6	10

Table 5. Sensory quality of waxed, cling film wrapped and control oranges at the end of the storage period of 24 days at R.T.

Treatments		Sensory qualities					
		Appearance	Juiciness	Taste	Aroma	Overall quality	Total of 10 scores
Control R.T.		1.3±1.3	1.5±1.4	1.9±1.8	2.2±1.8	1.8±1.4	1.8±1.5
Control L.T.		4.2±2.3	3.5±1.5	4.0±2.4	4.3±2.0	3.8±2.1	4.0±2.0
Cling film		5.1±1.2	5.0±1.8	5.1±1.5	5.1±1.5	5.4±1.6	5.1±1.5
Old wax emulsion	6%	5.1±0.15	5.2±1.7	4.6±1.1	4.7±0.9	4.7±0.9	4.9±1.3
–do–	12%	5.2±0.9	5.6±1.3	5.4±1.5	5.6±1.6	5.5±1.0	5.4±1.3
New wax emulsion	6%	4.9±1.4	5.2±1.3	5.7±1.5	5.2±1.4	5.7±1.6	5.3±1.4
–do–	12%	6.4±1.5	5.6±1.3	5.3±1.2	5.0±1.1	5.2±1.0	5.5±1.3
–do–	18%	6.5±1.1	5.4±1.3	4.7±1.3	4.7±1.1	4.5±0.9	5.2±1.3

Scale parameters: Degree of freedom 9 for each parameter and 49 for total score

*For sensory evaluation a few oranges wrapped in cling film were stored at 5°C during the course of this experiment and used for comparison as control L.T.

of PLW is suprisingly proportional to the concentration as was observed in the WVTR on coated papers.

The percentage wastage due to microbial spoilage was maximum among control fruits compared to fruits wrapped in cling film and those treated with new wax formulation. At the end of the storage period of 20 days, 20% microbial spoilage was observed among control fruits as against 8% spoilage among oranges wrapped in cling film. The spoilage among oranges treated with new/old wax emulsions formulation ranged between 2 and 12%.

The data on the sensory quality variations in oranges treated with different wax formulation wrapped in cling film subjected to sensory evaluation at the end of the storage period of 28 days at ambient condition are given in table 5. It is evident that, oranges treated with wax emulsions both old and new formulations scored equal to the cling film wrapped oranges. In fact, slight superiority in appearance was observed with new wax formulation at 12 and 18% concentrations which is probably due to the control of moisture losses from the peel, as well as due to better orange colour developed as a result of better air permeability of waxes particularly when the film is uneven on oranges. In fact this may probably be the reason why the oranges coated with wax emulsion containing 18% solids was still rated as equal to that of cling film.

From the data presented on air permeability and WVTR of kraft papers and cling film itc an be noted that new wax formulation at concentration of 9 and 12% had better air permeability of coated papers compared to old wax formulation. The air permeabi-

lity of new emulsion at 15% is almost equal to old formulation at 12% and slightly less than the cling film. The WVTR of new formulation at all concentrations was less compared to old wax formulation.

Different concentration and compositions of the wax emulsions tried on oranges showed that the reduction in PLW is not so directly proportional to the concentration of the wax solids in the emulsion whereas the reduction in WVTR of the papers coated with wax emulsion showed a more direct proportion with the increase in solids of the emulsion used for coating the kraft papers Table 6. This difference in behaviour is probably due to an even and uniform coating on the smooth surface of the paper while the rugged surface of the orange may not permit a uniform layer formulation. Hence, because of the uneven film formulation on the fruit surface the reduction in PLW observed due to the application of different wax emulsions may have to be explained as due to the wax particles penetrating into the pores on the surface of the fruit rather than due to the film that is formed thus resulting in inadequate restriction of cuticular transpiration. The recent reports indicate that the PLW due to transpiration could not be fully attributed to the transpiration taking place through stomata or lenticles. There is increasing evidence that the transpirational loss of water vapour in fruits occurring through the cuticle is much greater than what it was earlier thought to be, as the waxes of the cuticle are loosely arranged plates on the surface of the fruits rather than a rigid film.

The data on the comparative changes in the physicochemical constituents of the oranges treated with different concentrations of wax emulsions (ana-

Table 6. Air permeability and WVTR of craft papers coated with different wax compositions and concentrations

Treatments		Air Permeability			Water vapour transmission rate	
		Time in sec. per 200 ml air std. deviation	Rate ml/min.	Percentage reduction	Rate $g/m^2/24$ hr. @38°C & 90%RH	% Reduction
Control (craft paper)		24.6± 0.47	488	—	3744±404	—
Cling film wrapped		324	37	92.4	100± 66	97.3
Old wax emulsion	6%	82.0± 2.0	146	70.1	3360±512	10.3
–do–	9%	367.0±11.5	33	93.2	2926±338	27.2
–do–	12%	465.0±21.2	26	94.7	1936±154	48.3
New wax emulsion	6%	85.0± 1.2	141	71.1	2975±298	20.5
–do–	9%	142.0± 2.8	85	82.6	2551±261	31.9
–do–	12%	148.0±14.4	81	83.5	1876±130	49.9
–do–	15%	485.0± 7.1	25	94.9	1398± 81	62.7
–do–	18%	1800	7	98.6	525± 40	86.0

All wax emulsions were pressure homogenized

Table 7. Initial and final moisture, acidity, TSS and pulp to peel ratio in treated oranges during storage at R.T.

Treatments		Pulp to peel ratio	Moisture content of pulp	Moisture content of peel	Acidity %	Degree brix
Initial		3.44	35.4	70.3	1.06	11
				21 days after storage		
Control		4.91	79.57	32.59	0.42	10
Cling film wrapped		2.95	82.03	69.57	0.31	8
Old wax emulsion	6%	3.95	84.46	59.26	0.43	9
–do–	12%	2.76	84.31	66.66	0.32	10
New wax emulsion	9%	3.52	83.47	54.88	—	—
–do–	12%	3.69	84.41	62.32	—	—
–do–	18%	3.55	84.97	61.64	0.48	10

lysis done only for promising treatments subjected to sensory evaluation at the end) are given in Table 7. The pulp to peel ratio, which was initially 3.44, remained more or less equal to initial value in treatments. Cling film, old wax emulsion 12%, new wax formulation of 9, 12 and 18% concentrations as against on increase in the pulp to peel ratio to 4.91 in the control, as a result of loss in weight of the peel. This loss in weight is clearly reflected in the moisture content of both pulp and the peel. In the different treatments, although there is a decrease in the moisture content of both pulp and peel, the decrease was not as much as in the control.

The acidity, as well as the total soluble solids (°Brix) of the oranges reduced in general and more being in acidity, probably due to advancement in ripening of the oranges during storage.

From the above studies it can be concluded that cling film reduces PLW of both big and small size apples stored at RT as well as 32-35°F. The reduction in PLW and shrivelling was more in big size fruits than small size fruits stored at 32-35°F. New wax formulation reduced PLW almost comparable to cling film although old wax formulation had little control over the PLW and shrivelling in apples at TR as well as 32-35°F.

The composition and relative proportions of the different component waxes play a significant role in its air permeability and WVTR of the coated papers. The difference in the behaviour of apples and oranges coated with different concentrations of emulsions is mainly due to the nature of the fruit surface. Although none of the wax formulations were equal to cling film in reducing PLW and shrivelling, comparatively the oranges treated with 12% and above concentrations of emulsion were equal or superior to cling films for taste, aroma and appearance.

Nylon — 6 Film - A Revolution in the Packaging Industry

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ABSTRACT

The properties of nylon films and the advantages of using them in packaging of food products are given. Comparison with other packaging materials has also been made.

Nylon-6 is the polymer obtained by polymerisation of Caprolactam in the presence of catalyst and other additives. Nylon-6 is already known as a versatile engineering plastic for the moulded items. Recent technique of extrusion of nylon films in various countries has opened new vistas for this product. Nylons are general terms used for various combinations of polymers such as Nylon-6, Nylon-6, 6, Nylon-10, Nylon-11, Nylon-12, etc. In this paper importance is given to Nylon-6 considering the Indian markets and availability of the product in India in plenty. The basic properties of Nylon before processing the material will be as follows:—

1. Relative Viscosity : 4.5
2. Density : 1.13 gms/cm^3
3. Heat Distortion Temp. : 160°C.

Nylon films could be processed on indigenous extruders ranging from 15 microns and above in Layflat systems. Extruders must have the screws suitable to process Nylon because of sharp melting point. Screws having L:D ratio 1:24 in case of ordinary extruders and 1:14 in case of adiabatic extruders are normally recommended. The conventional extruders for HMHD film can be utilised for trial production but it is recommended to have a nylon screw having sudden compression as Nylon-6 is having sharp melting point of 215°C.

For the manufacture of Nylon-6 films high viscosity grades have proved to be suitable and acceptable. The higher the required temperature of the tube, the higher should be the viscosity of the basic resin. Transparency also improves with increased viscosity, although it is affected by intensity and temperature of cooling air. Intensified cooling leads to Amorphous film, which means better transparency and tube drawing properties can be achieved. Optimum film characteristics are obtained with a blowing ratio of 1:2 and 1:4 to go with winding speed of 10-15 meters per minute and temperature of 10-15°C with cooling air. The Angle of the bubble guide bolts should be kept as nearer as possible and the latter also should need to be as close as possible to the roller's nip so that wrinkling can be avoided. Transparent films with excellent tube drawing properties can be obtained by extrusion of Nylon-6 extrusion through slot dies. The extruded melt is substantially cooled with polished chilled rolls. The relevant temperature varies between 85-110°C. Its setting depends upon the desired thickness of the film, the speed of the dry rollers as well as the required properties of the film. Lower temperature of the rollers result in transparent film suitable for tube drawing. Lower cooling in turn creates films of increased crystallinity. The properties of the nylon film have been discussed above and one has to consider the cost benefit as well as the appropriate dies while using nylon films.

Properties of Film

1. High Mechanical Strength
2. High Elongation capacity.
3. Excellent resistance to cutting, perforation, abrasion and bursting.
4. Low shrinkage
5. Availability in different colours
6. Having lowest specific gravity amongst barrier films
7. Properties unchanged between —30°C+ 120°C.
8. High Chemical resistance to oils and fats and unaffected by most organic and inorganic chemicals except for minerals, formic and phenolic acids,

9. Outstanding impermeability to gases and vapours
10. Suitable for continuous rotogravure and flexographic colour printing.

Applications could be considered on the following properties:—

Physical properties—

—Tensile strength

—Bursting strength

—Heat Sealability

Barrier properties—

—Oxygen and Nitrogen Barrier

—Moisture

—Chemical resistance.

Table No. 1, 2 and 3 gives physical properties and their comparison with other thermoplastics, barrier properties and yield.

Table No. 1. Physical Properties in Comparison with Other Thermoplastics

	Tensile Strength Kg/cm²	Elongation %	Bursting strength 25 Microns (Mullen)	Heat sealability
LDPE	150	500	10-12	120-200°C
Ionomer	150	500	-	95-200°C
HDPE	250	300	Poor	140-180°C
Polyester	1700	75	55-80	Needs Coating
PP	400	300	Poor	Needs coating
Nylon	800	400	Elongates	High impulse

Table 2. Barrier Properties in comparison with other thermoplastic films

	Oxygen cc/M²/24 hr 25 Microns	Nitrogen gms/M²/24 hr 25 Microns	Moisture 25* Microns	Grease & Oils
LDPE	8000	3000	20	Fair to Poor
Ionomer	8000	3000	25	Excellent
HDPE	2500	650	5	Good
PP	3000	700	10	Good
Polyester	50	13	20	Excellent
Nylon	40	13	250	Excellent

*WVTR units gm/sqm/day under 90r. RH guardient at 38°C.

Table 3. Yield Characteristics

	Clarity	Yield m²/kg. thickness 25 Micron	Resin Cost Rs./kg.	Film Cost Rs./M²
LDPE	Transparent to Translucent	43	Rs. 20-22	1.25 (50 Microns)
HDPE	Transparent to translucent	41	Rs. 20-22	1.25 (50 Microns)
Polyester (oriented)	Transparent	—	Rs. 100 (film)	3.85 (25 Microns)
Ionomer	Transparent	40	Rs. 85	4.50 (50 Microns) 5.00
Polyester (Metallized)	Opaque	30	Rs. 175 to Rs. 180 (film)	6.45 (25 Microns)
Nylon	Transparent to translucent	34	Rs. 50	2.25 (25 Microns)
Nylon/CXA/Surlyn 35/10/40	Transparent	13 M²/Kg (85 micron thickness)	Rs. 50 Nylon Rs. 65 CXA Rs. 85 Surlyn	9.00 (85 Microns)

Applications of Nylon Films

Following applications of Nylon films are note worthy:

—Thermoforming packets for food products (approval by Food Authorities pending)

—Envelopes and bags

—Packaging of Motor oils

—Packaging of Bitumen

—Grease packaging

—Reinforcing of other products like Rubber, Leather, Fabrics

—Reinforcing with conveyor belts and other ribbons

—Dental Prosthesis for releasing moulded pieces from the mould

—Nylon-6 films could be metallised to improve moisture barrier properties and such films could be utilised for packaging of material where aroma retention is important.

—Nylon-6 film could be velvetised by electrostatic means with Nylon, Rayon or Cotton fibres in different colours. This has wide market potential in the manufacture of suitcases, handbags, belts, straps, slippers and tapes filled with other materials.

—All nylon films could be laminated with other thermoplastics for suitable economic applications. Lamination with other thermoplastics like Polypropylene, LDPE or HDPE would require adhesive layer like Ionomir, modified EVA ADMER or Plexar with minimum thickness.

—Nylon-6 Could be adhesive bonded to paper to form one side transparent, peel-open pouch that can be either gas or steam sterilized.

—Other applications include:—

—Gasketing

—Pressure Sensitive tapes

—Metallised roll-leaf

—Decorative lables

A Case Study

As a case study the packaging of bitumen is considered in Nylon-6 film. The present drums of 180 kgs. costs amount Rs. 150/drum. It has been observed that there is a wastage of 15-20% when the material from the drum is melted and transfered for applications. The filling of bitumen is done at 115 C to 120 C which takes lot of time for cooling. he space required for storing drums is also large.

All the problems mentioned above could be avoided if Nylon-6 film is used suitably in 25 kgs. pack.

Nylon-6 can withstand the filling temperature and at the same time, cooling to solidify material could be achieved. The main advantage would be that the bag itself could be melted along with the content at the time of final application. There is not a single kg. wastage but molten Nylon would act as filler to reinforce the application area.

BONF (Biaxial Oriented Tubular Nylon Film) Biaxial Oriented Tubular Nylon Film (BONF) is done to increase the mechanical properties of the film and to reduce the thickness. It also yields high resistance to puncture and bursting. The transparency of the film along with brightness also would be improved by biaxial orientation.

The improvement in the mechanical properties has made BONF suitable for extreme temperature applicability. It can withstand temperature range from-60 to 130°C. It also withstands autoclave sterilisation.

BONF also has high abrasion resistance, hence excellent adhesion to various sub-strates and high recovery from folding is possible. Lamination to other substrates is easy in BONF. The advantage of properties like high tensile strength and tear resistance could be utilised to reinforce other products such as rubber, leather, fabrics or other materials for technical uses. BONF is particularly suitable for production of adhesive tapes because of its high tensile strength. A thinner film at lower cost could be utilised.

BONF can be metallised under vacuum with metals. It can easily replace tripple laminates of LDPE, Aluminium Foil and PP in the field of packaging.

Some properties of BONF:

Thickness	: 15 Microns
Specific Gravity	: 1.150
Tensile Strength	: 2170 Kg/Cm^2-2485 kg/Cm^2
Elongation	: 90—110%
Impact Strength	: 11
Thermal Shrinkage	: 0.7%
Oxygen permeability	: 30 cc/m^2/24 h atm.
Printability	: Without treatment

One of the important applications of oriented nylon films is for the production of laminated sheets. The metallised Nylon film has a large outlet in the days of scarcity of aluminium foil. This would also compete with polyester metallised film in the fields of packaging of food stuffs like chocolate wraps, cheese packing, butter packing etc. Appropriate techniques of Form, Fill & Seal machines and different types of sealing including horizontal forming and packaging for different articles can be explored.

Because of high tensile strength and tear strength, Nylon film can be used to reinforce other products such as Rubber, Leather, Fabrics and also materials for technical use which are put to friction or possible abrasion in contact with foods and oils and other fluids. In particular application it can be used in conveyor belts and other ribbons.

Lamination

Further process as explained earlier and biaxially oriented metallising widens the area of combination with different materials and substrates. e. g. Nylon film can be laminated with aluminium or paper with proper adhesive and different packaging areas can be explored, for instance packaging of ball bearings and engineering items where grease is used, this film can be of great use.

Coextruded Films:

The concept of co-extruded films started with the ideas that most of the polymers were tried by extrusion by flat die or tubular blown film which had good properties for few applications but drawbacks at other end. To utilise the best properties of thermoplastics techno-economically the idea of co-extrusion of different polymers took shape. The requirement of basic packaging of any product are following; however, the functionality of final product has to be kept in mind.

Protection:

The properties considered here are—

—Water vapour barrier

—Oxygen barrier

—Other gases barrier

—Resistance to Cryogenic temperatures

—Resistance to fats—specially for food products

—Light barrier

—Tear Strength

—Folding endurance

—Resistance to odours

—Resistance to bursting i. e. Puncture Resistance

—Physical properties.

Packaging

This factor is governed by

—suitability of packaging material for different packaging machineries.

—Sealability

—Thermo-forming characteristics

—Speed of packaging

—Cost of packaging.

Distribution

This factor is very important as the final user of this product must get the packed product in absolutely intact condition. For selecting packaging material this factor is governed by—

—Resistance to handling

—Resistance to transportation

—Abrasion resistance

—Resistance to aging

—Cost

—Consideration to different storing/warehousing conditions.

Presentation

The presentation to the customer or sales appeals is an important factor to be noted for right selection of the material. The following properties are considered:—

—Transparency where display of products either directly or through windows is important

—Printability

—Gloss

—Sandwich printing

—Easy opening

—Ease of destruction

—Cost

Technology of Coextrusion

The technology of co-extrusion which is most popular today for faster and economic production is extrusion of different polymers through different extruders which are suitably made as per the polymer

flow characteristics and combining them at a common die as different layers. These layers are combined just before the die head and then blown by compressed air which forms the bubble between the the die head and nip rollers. The nip rollers make the tubular film in lay flats which is passed on to the winding and slitting unit. The compressed air settles the bubble when air value is shut off. The stability of bubble is important to create uniform width in the lay flats which avoids wastage during slitting. The thickness of the film would be controlled by speeds of the extruders, temperature programme and speed of the nip rollers.

This extrusion could be considered depending upon applications and number of layers could be decided as

—Two layers
—Three layers
—Five layers or more.

With two extruders it is possible to have three layers composite, at the same time five layers composite could be produced with three extruders by utilising a proper die.

Coextrusion of different layers by flat die extrusion is also possible and is being used in some countries where in-line thermoforming is used. The thermoformed product is then converted to cold blowing to form bottles having different laminates.

Extrusion lamination on substrate like paper, aluminium or thermoplastic film to form different composite structure is also considered to be important as normal blown techniques are not possible. However, extrusion lamination of one polymer to other polymer substrate gives better control over thickness and width control.

Case History

Bearing in mind all the above aspects mentioned earlier, an example of packaging fruit juice can be cited. The initial construction was aluminium foil coated with polyethylene when it started replacing cans and bottles which required lot of space and weight problems during shipping. However, in Sweden, they found with a new pouch that citric acid eventually permeates the polyolefin coating and attack the foil interface film spoiling the initial good adhesion which also resulted in degradation of juice, flavours, colour and vitamin C content.

The solution was found which was a construction of LDPE/Print Paper Board/PE/AL Foil/Ionomer/LDPE. However, with the introduction of Nylon/Ionomer structure pouch making has considerably saved the cost as well as retention of juice flavour, easy handling and shelf-life of approximately 2 months. To select proper combination, however, barrier properties are taken into consideration.

ANNEXURES

Table 1. Estimated Potential of Nylon-6 in Packaging of Products

Product	Domestic Supply & Export	Considering 5% of Supply Changed over to Co EX film pouch packing	Nylon-6 raw material requirement (Estimated)		Remarks
Edible Oil	13 Lakhs Tons (prodn. 1980)	65,000 Tons	1/2 kg. Pouch packing	165 T	50% of 65,000 Tons
			1 kg. Pouch packing	165 T	50% of 65,000 Tons
Vanaspati Ghee	5 Lakhs Tons (prodn. 1980)	25,000 Tons	1/2 kg. Pouch packing	33 T	50% of 25,000 Tons
			1 kg. pouch packing	33 T	50% of 25,000 Tons
Motor oil & Grease	9 Lakhs Tons (prodn. 1979)	90,000 Tons (10% of total)	1/2 kg. pouch packing	250 T	Entire 28,000 T in 1/2 kg. pouches
Spice	8.5 Lakhs Tons	42,000 Tons	1/2 kg. pouch packing	55 T	50% of 42,000 T.
			1 kg. pouch packing	55 T	50% of 42,000 T.
Coffee	1 Lakhs tons	5,000 Tons	1/2 kg. pouch packing	15 T	Entire 5000 T in 1/2 kg. pouch.
				771 T	

Total estimated consumption of nylon-6 for the above said products works out to 771 Tons/year even if only 5% of production is packed in Co-extruded film pouches.

Table 2. Application of Coexruded Film and Laminated Composites

Composite/Coextruded film with structure	Applications
1. Nylon 6/Ionomer (35/45 Microns)	Packaging of Edible oil, Ghee, Motor oil, Grease (for extended product shelf life)
2. LDPE/Ionomer/Nylon-6 Ionomer/LDPE (30/5/25/5/30 Microns)	Packaging of Meat, Cheese, Nuts, Snacks etc. Packaging of fresh meat and fish for exports even through inert gas flushing
3. Nylon-6/Ionomer/LDPE (25/5/40 Microns)	Packaging of food,-products, papad for exports.
4. Nylon-6/EVA	Packaging of spray dried milk powder, Bournvita etc.
5. Nylon-6/Ionomer/LDPE or Nylon/EVA	Packaging of spices, dried fruits, Coffee papad etc.
6. Metallised Nylon 6/ Ionomer/LDPE	Packaging of roasted coffee.

Table 3. Comparison of Cost, Capacity Barrier Properties & shelf Life

Type	Capacity kg.	Cost Rs. per Unit.	Barrier Prop.	Product shelf life in months
Tin packing	1	3.00	F	2
HDPE Jar	1	2.25	G	3
HD/LD Composite	1	0.35—0.40	G	2 months for ghee 1 months for Oil
Nylon/Ionomer/LD	1	1.00 approx*	E	2 to 3.
Nylon/Ionomer or Nylon/EVA	1	1.25 Approx*	E	More than 3, if sterilised then product life can be extended

*(Depending on structure)

Table 4. Cost Calculations

Composites (Thickness in Microns)	*Raw Materials Cost of Rs./M^2 of film (With thickness Mentioned)
1. Nylon/CXA/Surlyn (35/10/45—90 Microns)	7.0
2. Nylon-6/EVA (40/55—95 Microns)	6.00
3. Nylon-6/Ionomer/LDPE (15/10/60—85 Microns)	5.0
4. LDPE/Ionomer/Nylon/Ionomer/LDPE	5.50
5. HDPE/LDPE (70/70—140 microns)	4.00

*Cost of raw material considered taken equal to HDPE/LDPE @ Rs. 20/kg., Nylon 6 @50/kg., Ionomer Rs. 80/kg., EVA Rs. 60/kg.

Aluminium in Packaging Industry

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ABSTRACT

The need for introduction of aluminium container in food packaging industry has been highlighted. Application of aluminium cans for packing processed food products and beverages has been discussed. The use of aluminium collapsible tubes for pharmaceuticals has been mentioned.

Introduction

Modern Packaging system has become necessary to move in pace with time and to keep in step with competitors. The concept of packing food and beverages is in existence from a long time. But, with the advancement of the civilisation, the market for packed foods has developed vastly. The Indian people, though earlier used very little packed foodstuffs, have changed their way of thinking, by accepting ready made Foods packed in attractive containers. Also, as the style of living has changed, this has also necessiated to accept packed foods which are readily available in the market.

The packing of foodstuffs and beverages, in tin cans is a very common practice and has been in existence from a considerable time. But, in India, there being a shortage of tin, there has been a necessity to Import tin sheets. Infact local (indigenous production of tin which was 80,000 tonnes in 1973 has dropped to 64,000 tonnes in 1981 though the demand is around 180,000 tonnes per annum. It is a drainage on the Indian foreign exchange.

In order to overcome this, Indian Packaging Industry could give a thought using other material such as aluminium. Aluminium is richly available in India and this would save foreign exchange expenditure on imports.

Further, the ever increasing cost of packing in glass bottles, has forced the manufacturers of food products and beverages to go into other types of packing such as "Proved Aluminium" containers. Also, the packaging of foodstuffs in plastics, which is a Petroleum based product needs considerable thinking as it involves foreign exchange as India does not produce plastics of very high "Proved type" which can be used in packaging foods.

Aluminium cans were first used in Scandinavia and Switzerland for packaging of fish, milk, meat and vegetables. Presently, aluminium cans are used quite extensively in all advanced countries for packaging soft drinks, beer, food stuffs, pesticides etc. etc. The inherent advantages of aluminium as a food packaging material are:

(a) Lesser transport cost due to reduction in weight.
(b) Non—toxic.
(c) Good (atmospheric) corrosion resistance.
(d) Easy to work.
(e) Attractive finish.
(f) Readily decorative property.
(g) Excellent thermal properties.
(h) Readily it can be recycled.

Aluminium And Corrosion

Aluminium in general displays excellent resistance to a wide range of corrosive agents.

The good corrosion resistance of aluminium depends on the presence of a thin inert and protective surface film of aluminium oxide. The oxide film thickens with age in air and in aqueous solutions. When film is dissolved, as in certain chemicals, the metal corrodes.

The addition of alloying elements to pure aluminium influences its corrosion resistance properties, imparts strength and improves formability characteristics.

Application of Aluminium Cans:

The use of aluminium cans in food packaging can be divided into two groups as follows:

Group A—Processed Foods:

1. Fruit/Fruit juices.
2. Vegetables.
3. Sea foods.
4. Meat and Poultry.
5. Dairy Products.
6. Dry packed products such as coffee, milk powder etc.

Group B—Beverages:

1. Beer.
2. Soft Drinks

Shallow drawn aluminium cans are used extensively for processed foods such as vegetables, sardines, small herring, certain meat products, fillets of large fish in oil or various sauces.

Deeper cans either drawn and ironed or impact extruded are used for vegetables in brine or sauces, soups.

Fruits and Vegetables:

The shelf life of canned fruits and tomato products packed in plain aluminium cans are limited. Canned vegetables, other than tomatoes show some difference between plain and coated aluminium cans. But for a satisfactory shelf life internal coating on aluminium can be considered. Aluminium cans are also used for aseptically canned bean dip, bean salad and green beans.

It has been reported that canned corn yields an exceptionally high quality product when packed in plain aluminium cans.

Chilli with beans and dehydrated Soups are packed in shallow D.I. cans.

Sea foods and meat products:

Shallow drawn cans are used for canned sardines, tuma, crab meat and lobster.

Crab and lobster packed in aluminium cans do not require parchment lining to avoid discolouration of the product. Sardines prepared in tomato sauce and mustard sauce, if to be packed in aluminium can, should not exceed total 3% acidity, expressed as acetic acid. Tomato sauce and mustard sauce are corrosive products that can attack internally coated metal containers.

Other flesh foods packed in shallow D I cans include potted meats, luncheon meats (dry), corn beef hash and boned chicken.

Dehydrated Vegetables:

An ideal container for dehydrated vegetables is metal cans. If the cans are reinforced to prevent collapse under vacuum or if the cans are tightly filled—as it should be—so the dry product will support the walls, the filled cans may be sealed under vacuum. The vacuum protects against oxidate changes and kills insect life or prevents its development.

Powdered vegetables are also packed in cans.

Dry Packed Products:

A few Products like roasted coffee, milk powder are canned in dry state. This obviates heat processing and canning in such cases prevents loss of volatiles, moisture pick-up by hygroscopic powders etc. Dry Packed foods may be hermetically sealed under vacuum or sealed in an inert gas such as nitrogen, thus, preventing development of off-flavours through oxidation of fatty acids.

For several days after roasting and grinding the ground coffee gives off gases that increase the pressure inside the cans. Most high volume coffee packers give the ground coffee a "gas—off" step between grinding and packing.

Beer and Carbonated Beverages:

Aluminium Cans manufactured by impact extrusion method are extensively used for pasteurized beverages such as beer and soft drinks.

Beer contains Carbonic gas and when it is pasteurized after sealing (to extend the shelf life) the internal pressures may rise to ten times the pressures in food cans. The beer can, therefore, has to be designed to contain pressure of 100 lbs/sq. inch. (7.0 kg/cm^2).

MESSRS. KLAS ENGINEERING PRIVATE LIMITED, BANGALORE, have come out with

aluminium Cans for packaging beer, jam, fruit Juices and Condensed Milk. Many experiments have been carried out to study the shelf life of beer canned in two-piece Aluminium Cans. Aluminium of 99.8/99.9% purity has been used to manufacture the two piece cans without internal coating. It has been observed that the beer has not been affected even after 7/8 months storage. The experiments for storage life have been carried out successfully by Indian Institute of Science, Bangalore and also at M/s. Doburg Lager Breweries, Satara in their respective Laboratories. The Aluminium Cans brought out by M/s. Klas Engineering Pvt. Ltd., have an attractive printing also on them.

Also experiments are being conducted by C.F.T.R.I., Mysore, on the Aluminium Cans packed with food products for shelf life where some of them may require internal coating.

The aluminium bottles manufactured in differen capacities of 100 ml, 250 ml, 500 ml and one litre are all used extensively for packing pesticides by Messrs. Bayers, Rallis and Sandoz Companies.

They have also brought out aluminium collapsible tubes used in packing pharmaceuticals and other ordinary uses in limited field without any coating. In some cases of packaging internal coating of these tubes may be a necessity.

With the increase in the production of aluminium in the Country by 1987, Indian packaging Industries could find ways and means to use more and more aluminium. The temporary shortages experienced in the market should not be taken as a basis as India will be not only be self sufficient in aluminium, but also will have surplus aluminium in years to come for export market also.

Materials and Forms of Packaging

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ABSTRACT

The increase in the standard of living has brought about changes in the marketing and distribution of goods. To economise the cost of packaging newer or alternative systems of packaging are being introduced, as exemplified by form-fill-seal packages, lined cartons standup pouches and Thermaformed containers. There is great scope for new systems for ready-to-eat foods.

With increase in standard of living, changes in the marketing and distribution of consumer foods and greater demand for ready to serve foods the types of packaging has seen a distinct change in recent years. In view of the fact, that the percentage of women taking up jobs has increased, the need for easy to cook foods to save time has also had an effect on the consumer packaging.

In addition, because of steep increase in the cost of tin cans glass and paper board the packaging industry has come up with alternatives to bring downcosts without sacrificing the functional quality of the package.

In order to check adulteration and spurious articles, pilferproof small packs are in great demand. The need for quality foods in smaller packing has also increased the demand for portion packs.

Various systems of packaging are already in vogue which will be dealt in detail in the following paragraphs.

Form Fill & Seal (FFS)

It is the most popular pack for milk and it has already replaced milk bottles. Inspite of minor disadvantages it is well accepted. Many food articles, both raw materials as well as finished products in the form of liquids, powders and solids are being packed by this system of packaging.

The quality of web material used for this type of packaging depends on the protection required by the product.

Already we have in the western region of the country aseptically packed milk in tetrapack containers which does not require storage under refrigerated conditions.

Lined Cartons:

The lined carton is made of an inner layer of barrier material which is STUCK inside the carton. The nature of the barrier material varies depending on the protection required, some of the liners used are paper/LDPE, and PAPER/FOIL/LDPE.

The length of the liners are so chosen that once opened it will be difficult to reseal. The above system has brought down the cost of packaging of many foods which were otherwise packed in tin containers and glass bottles.

Coated and Laminated Cartons:

The carton could be made from a coated or a laminated board and the pilfer-proof protective seal is achieved with a membrane sealed at either end.

The above packaging systems are offered as a package deal by manufacturers who supply the packaging material as well as the machines for filling and sealing.

Stand up Pouch System:

These pouches come in a flat form and when filled with material takes a rigid shape and can stand on its own base as a stable pack. This is in contrast to the ordinary pouches which can be placed only in a flat condition. The stand up pouches in addition to having rigidity has a attractive printable surface which is a must in today's competitive super-markets where impulse buying has a important role.

In addition there is a considerable savings in the use of packaging materials by this system.

Thermo Formed Containers:

The thermoformed containers could be filled with the product and heat sealed with a barrier material. This system is popular for portion packs, such as jams, tomato ketchup, pickles etc.. Currently a pack which is most popular in the western region is the "SHRIKAND" PACK marked by Amul in units of 100 and 500 gms. In addition other dairies have put up small packs with tight fitting lids. The small packs have become very popular in airlines and hotels.

The packaging industry has geared itself to meet the challenge of coming years and considerable capacity has been established with sophisticated imported equipment as well as indigenous automatic, semi-automatic and manual equipment.

Looking at the recent trend in packaging in advanced countries it will not be very long when we will have many more systems of new packaging for ready to eat consumer food products.

Coextrusions in Food Packaging

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A coextrusion is the combination of two or more thermoplastic polymers into a single homogeneous web in a single processing step. Such combinations are resorted to when all the end-use requirements, including cost, of a web are not completely met by just one material. So diverse and exhaustive is the range of materials available today that a suitable combination can be designed and tailormade for almost any end-use requirement.

Coextrusion involves the simultaneous extrusion of a no. of polymers and the subsequent combination of the melt streams into the required layer sequence to form a multi-layered sheet or film structure. Coextrusions can be used either by themselves or in further combination with non-plastic substrates.

Coextrusion has now become the functionally ideal and the most economical process for the combination of different polymers. It has tremendous advantages over other lamination process in that:

It enables the production of much lower thicknesses of individual plies.

It does not use adhesives and eliminates problems associated with adhesive leaching, residual solvents or moisture and the handling of flammable and volatile materials in the plant.

It produces much higher inter-layer bond strengths.

Unstable high-barrier resins like EVOH can now be utilised by sandwiching them.

Pigmentation can be obtained without sacrificing surface properties by sandwiching the pigmented layer between transparent layers; this also adds gloss to the surface.

Pinholing is totally eliminated.

It eliminates curling problems by producing symmetrical structures in one operation.

It gives much higher output rates.

It enables scrap to be recycled as a sandwich layer without sacrificing on functional properties. Apart from cost reduction, this also solves environmental problems.

And, of course, any number of polymers and operations like embossing and corona discharge treatment can be achieved in just one operation using just one production crew.

Growth and Applications:

The development of coextrusions took place mainly in Europe, Japan and the USA. and its growth there has been nothing short of meteoric. In the USA, for example, it has grown by a phenomenal 756% from 76,500 MT in 1976 to an estimated 655,000 MT in 1983.

The major areas where coextrusions have found use are packaging—in particular food packaging—and other industrial applications involving effective formability and high strength-to-weight ratios.

Polymer Selection:

The selection of the individual components of a coextrusion and their thicknesses will depend largely on the end-use requirements of the structure. By incorporating different polymers in the correct layer sequence, the required combination of their physical and chemical properties can be obtained in the ultimate composite. It is important not only to use optimum thicknesses of the various materials to obtain the desired properties but also to ensure that each ply lies in its proper position within the web. A layer used for its heatsealability, for example, must lie on the surface being sealed and on "appearance" layer must lie on the surface exposed to view. In packaging, it is normally ideal practice to place the most effective barrier layer closest to the product being packed.

In order to help decide on a suitable coextrusion combination, the relative properties of various resins and the resins for their use are given in the following tables:—

Table 1. Resin Properties

Resin	Specific Gravity	WVTR in Gms./100 in.^{2}/ 24 hrs. at 38°C & 90% R.H. 1 mil. Thickness	OXTR in Gms.-cc./100i n^2/ 24 hrs. at 38°C & 90% R.H. 1 mil. Thickness	Tensile strength At Break psi	Melting Temp. °C
LDPE	0.918—0.932	1.00— 1.50	350.00	1,200— 4,500	107—115
HDPE	0.945—0.965	0.30— 0.40	150.00	3,200— 4,500	130—137
LLDPE	0.918—0.935	0.50— 1.00	200.00	2,500— 4,500	120—130
PP	0.90 —0.91	0.25— 0.50	150.00	4,500— 6,000	168
Polyester (PET)	1.34 —1.39	1.00— 1.30	3,00—4.00	8,000—10,500	254
Ionomer	0.94	1.30— 1.60	380.00—530.00	5,000	80— 95
EVOH	1.14—1.19	13.90	0.01—0.10	—	—
PC	1.20	3.10	186.00	9,500	140—150
PETG	1.27	4.00	25.00	8,000—10,000	200—250
AN	1.15	3.50— 5.00	0.50—0.80	9,000	95
PS	1.04—1.06	7.00—10.00	350.00	5,200— 7,500	100—105
HIPS	1.03—1.06	7.00—10.00	250.00—350.00	2,700— 6,200	100—105
ABS	1.02—1.06	5.00—10.00	50.00—70.00	2,500— 8,000	88—120
Nylon—6	1.12—1.15	16.00—22.00	2.60	11,000—14,000	216
EVA	0.93	2.00—3.00	840.00	2,200— 4,000	103—108
PVC	1.30—1.60	0.90—5.10	5.00—20.00	1,000— 3,500	75—105
PVDC	1.65—1.72	0.10	0.05—0.15	2,800— 3,500	160—170

Table 2. Resins—Reasons for Use

Resins	Oxygen Barrier	Moisture Barrier	Grease Resistance	Toughness	Heat Sealability	Formability	Relative Cost
LDPE		■			■		Low
HDPE		■	■	■			Low
EVA		■			■		Medium
Polystyrene		■		■		■	Medium
Ionomers		■	■	■	■		High
Polypropylene		■		■		■	Low
PVC			■	■		■	Low
ABS		■	■	■		■	High
Polyester		■	■	■			High
PVDC	■	■	■				High
Nylon	■		■	■			Medium
EVOH	■						High
LLDPE		■		■	■		Medium

Packaging Systems with Special Reference to Lined Cartons

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Introduction

In today's consumer-oriented economy, a package is an extremely vital link between the manufacturer of product and the ultimate user. There is a greater awareness among the consumers today regarding their right to obtain proper *quality* and correct *quantity* of the product at a fair price, in an aesthetic and hygienic package. For manufacturers and packers of food products, these factors are of a critical nature as it is essential that the consumer gets the product in factory fresh condition. The implications of a consumer finding soggy biscuits, flavourless coffee or rancid milkpowder in the pack can be wall imagined.

Need for System Packaging:

With increased consumer-awarness, now-a-days various food products are sold in convenient packages. Food packers have the widest range of products to be packed in containers made from almost all kinds of basic packaging materials. So it follows that packaging operations have to be carefully designed and monitored to ensure that a package is used economically, efficiently and successfully.

There are three major elements in any packaging operation:

The Package: It should protect the product from enviornmental, transportation and handling hazards. It should also preserve the product without deterioration during the expected shelf life. And most important, it should convey necessary information such as quality, quantity, price, date of packing and brand name to take full advantage of "brand loyalty".

The Packaging Machinery: These machines should pack the product in required dosages without expensive variations, give the required output and be flexible enough to accommodate different pack sizes without major modifications.

The Operating and Maintenance Personnel: The people manning the packaging machines, should have sufficient skills to operate and maintain the machinery at rated outputs, within normal allowable spoilage.

It can be seen that there are problems of compatibility of the above three components especially in the case of mass produced items requiring high speed operations. It becomes difficult to pinpoint responsibility in the case of a malfunction in the packaging line on either the packaging material or the machine or the personnel.

System packaging came up as an answer to this problem and quickly became popular particularly in developed countries, with large scale packers. In essence, it means a single supplier of packaging materials and the packaging machinery, with training being provided to the operators and maintenance personnel by the supplier. The system supplier has to ensure compatibility of the above three elements by extensive trials at his end as well as the manufacturer cum Packer's.

Lined Carton System:

The lined carton—consists of a duplex board carton printed with required design and an inner heatsealable liner glued to the carton. The carton provides mechanical strength and makes the pack easy to handle and distribute. It also provides an excellent scope for decoration and multicolour printing. The heatsealable liner provides physical, chemical and biological protection i. e. it protects the contents from losing or absorbing moisture, from loss of aroma or odour pick-up, from oxidation and from the effect of light.

Lined cartons are characterized by flexibility and economy. They are also hygienic and pilferproof.

There is flexibility of varying the carton and liner material independently of each other. There is flexibility of format i. e. the carton length, width and height can be varied within wide limits. There is also flexibility of carton construction styles suitable

for mechanical packaging and which are convenient for the consumer to use.

Economy of lined cartons is reflected through efficient handling in technically advanced, throughly tested and proven packaging machines, ensuring a high degree of reliability and efficiency. Economy is also in terms of space utilization. Empty flat Cekatainers occupy 90% less storage space compared to rigid containers. When erected and filled they occupy 33% less space compared to round cans or bottles. In addition, there is also some economy in the raw material consumption compared to traditional bag-in-box mode of packaging. Used as a refill pack, lined cartons are cheaper by 20 to 40% compared to tin containers or glass bottles.

The lined cartons are hygienic as the inner contact layer of the liner is not touched by human hands either during the process of manufacture of the lined carton or during the packaging operations. This factor is of extreme importance for food product manufacturers. It is also not possible to substitute the product with spurious ones as the length of the liner is so adjusted that once opened, it cannot be resealed. Thus pilferage is also prevented.

Applications in Food Packaging:

The lined carton system with its inherent advantages, as explained above is an ideal solution to the problems posed by rigid containers as well as traditional flexible packs. The process of development of a lined carton for any product goes through well defined steps. These essentially relate to selection of proper lined material and requisite outer carton board. They also include designing surface graphics, and selecting suitable packaging machinery from the available range. The following information is thus required from the manufacturer of the product.

Physical Properties such as bulk density, quantity to be packed and pnysical state i. e. whether solid, semisolid or liquid.

Chemical Properties such as sensitivity to moisture gain/loss, aroma/flavour retention and degradability eg. whether susceptible to rancidity etc.

Production requirements such as packing output (in No. of cartons per hour/shift/day). flowability of product in weighing/dosing equipment and manpower constraints.

Marketing considerations such as shelf life, shelf appeal, distribution method and pattern and consumer convenience.

The carton dimensions are determined by bulk density, unit quantity to be packed and shelf appeal. The carton style depends upon consumer convenience. The carton board specifications are based on unit quantity to be packed and distribution methods and pattern.

The inner liner is selected keeping in mind the sensitivity to moisture gain/loss, aroma retention, gas barrier properties, required shelf-life and physical state of the product i. e. whether it is solid or semisolid or liquid.

The packaging machinery offered depends upon packing output required. Flow properties of the product e.g. whether it is free-flowing or sticky powder, granular or lumpy, pasty or liquid determine the speed of weighing/dosing equipment.

The Carton:

In terms of size, the smallest lined carton that can be produced is 135 cc and the largest 2700 cc. The grammage of duplex board used varies from 230 gsm to 450 gsm. Normally, cartons are provided with glue flaps on top and bottom. Tack-in flaps or flaps with tear-off and reclosure facility can also be provided.

The carton can be printed with multicolour graphics in 2 to 8 colours with good reproduction of half-tone designs. However, normally upto 4 colour printing is preferred due to lower cost. For preventing abrasion of the print due to constant rubbing in handling and transit, a scuff-resistant varnish coating can be given after printing. For oily products, a special fat-resistant varnish is available, which prevents staining of the carton during filling.

The Liner:

Generally LDPE coated paper is used as a liner for stable products such as tea or spices or glucose powder. The thickness of polyethylene can vary from 40 gauge (10 micron) to 300 gauge (75 micron).

A moisture barrier laminate of paper/Al-Foil/LDPE is used for hygroscopic products such as instant coffee or malted milkfoods. The thickness

of Al. Foil is generally 12 micron and sometimes 9 micron if lower shelf life is sufficient. An alternate moisture barrier is a laminate of paper/HDPE which is inferior to foil but cheaper. Biaxially oriented polypropylene (BOPP) can be used in place of HDPE but the adhesion during lamination is poor and the cost is appreciably higher.

For fat-containing products such as whole milk powder, baby foods, cheese, pure ghee, vegetable oils or roasted cashewnuts/peanuts, an excellent gas barrier is paper/metallised polyester/LDPE laminate. The metallised polyester has very low oxygen/nitrogen transmission rates and hence the lined carton can be vacuumised or nitrogen-flushed as desired. This liner can also be used for ground coffee or active dry yeast. The shelf life obtained varies from 6-8 months for ghee to l$\frac{1}{2}$ years for roasted cashewnuts.

When the product is vacuum-packed it is to be noted that the pack becomes brick hard due to atmospheric pressure on the liner, which compacts the product. However, when the liner is opened, the vacuum is broken and the product returns to its free-flowing state. As is well known, vacuumising reduces the oxygen level inside the pack and retards oxidative rancidity. Vacuumised packs are very popular abroad for products like ground coffee.

In the case of hygroscopic or oxygen-sensitive products, the carton is used only as a refill pack, because once opened, the liner cannot be resealed. Therefore, instructions have to be displayed on the carton to empty the contents in an airtight container immediately after the pack is opened.

For aroma retention, a PVDC coated substrate can be used due to its excellent barrier properties. However, such substrates have not yet found commercial applications in lined carton systems due to high cost.

The Machinery:

Wide variety of packaging and dosing machinery is available to suit a number of products.

The packaging machines range from high speed fully-automatic PA 80 operating at speeds of 60 packets per minute to pedal-operated heat sealer HSU which gives an output of 3 to 4 packets per minute. The two semi-automatic machines RT-2, RT-3 and the automatic RT-4 are suitable for medium outputs of 8 to 25 packets per minute. The machines are equipped to run cartons of any given size selected by the packer. Additional sizes can be run on the machine with sets of change-parts such as carton holders available at extra cost. All the machines are so designed that a user can switch from a slower machine to a faster one as his packing requirements increase, without any change in the carton or liner.

Four types of dosing/weighing machines are available:

Double Beam Weigher for free flowing products such as tea, with an output of 20-22 drops per minute.

Vibratory Feed Weigher for sticky products such as malted milkfoods, skim milk powder and lumpy products like extruded soya, with an output of 12-15 drops per minute.

Auger Feed Dozing equipment for difficult products like whole milk powder with an output of 15 to 18 drops per minute.

Liquid Filler for products like ghee or vanaspati with an output of 8 to 10 drops per minute.

Additional equipment is available against specific requirement. It includes serial number embossing for Agmark purposes, dust extractor, leaflet or spoon feeding unit etc.

For vacuum packaging/gas flushing operations, presently only a semi-automatic machine VP 46 is available. It accepts 4 packets placed inside the cabinet with bottom sealed and glued and top partially sealed. Vacuum is drawn and gas admitted, if required, through the unsealed portion of the top liner. The seal is then completed by means of sealing jaws inside the cabinet before the cartons are removed. The output is approx. 4-6 packets per minute.

Conclusion

In India, there is still some tendency to view packaging as a luxury. In these days of rising prices, the cost reduction axe invariably falls first on the packaging, resulting in derating existing specifications. Packaging is an integral part of total manufacturing operations for any product. Therefore, there is a need for upgrading packaging by use of modern systems, materials and methods, to give a better, value-added product. This will help the manufacturers to maintain uniform product quality in the consumers' hands with longer shelf life, larger

sales areas such as exports and less problems of stock rotation in shop-shelves.

In determining the total cost of a pack, the packaging material cost alone per se is of no consequence. What is to be determined is the total cost of reaching it to customer. It is often found that by increasing the packaging material cost slightly, the total cost comes down—however contradictory it may sound.

The quality of packaging will determine the quality of life and greater awarness of this fact among the manufacturers and users of packaging will help in raising the general standard of living.

DISCUSSION

SESSION I. — MATERIALS AND FORMS OF PACKAGING

Paper 1: The Welded Can— *U. D. Laad, Poysha Industrial Co., Bombay.*

Q. Does the Soudronic Superwima Process work with TFS and black—plate? *(V. Padmanabhan, ITL Pvt. Ltd., Bangalore)*

A. Yes, provided there is no rust in TFS. Cleaning should be done.

Q. Can we apply selected lacquers, i. e., AR & SR on to the inside of the superwima side seam?

A. Yes, it is possible to coat with A. R. or S. R. lacquer in cans welded by Superwima process. Internal side seams require strip lacquering in such cases.

Q. In the case of welding with copper wire, is it possible that copper gets into tin?

A. As tin melts earlier, there cannot be copper deposition earlier.

Paper 2: Functional Efficiency of Newer Packaging materials with reference to insect free packaging—*by K. S. Narasimhan, CFTRI, Mysore.*

Q. Is it possible to get a hand-book on this matter?

A. An abstract is published in the Souvenir. The full paper will be published in due course.

Paper 3: Effect of Polymeric Cling Film Wraps on the storage behaviour and sensory quality of apples and oranges during storage under refrigerated and ambient conditions—*by Dr. Habibunnisa, CFTRI, Mysore.*

Q. Has any work been done to prolong the storage life of mangoes, especially of *Totapuri* variety? If so, I would like to know the details (O. P. Dang, Ashoka Fruits Ltd, Bangalore)

A. We have not carried out studies on *Totapuri* but have conducted studies on *Raspuri* Variety.

Q. What is polymeric cling film? What was the thickness of the film used in the studies? (H.B.N. Murthy, Bangalore).

A. Cling film is a film which sticks to itself by applying a little pressure. The film has an adhesive coating and is manufactured by the ACCI of India. The film is basically low density polyethylene.

Q. Which are the other films you have used? (Singh, I.P.C.L, Baroda)

A. We have used only polyethylene.

Comment by Singh: For Cling film, we feel either EVA copolymer or plasticised PVC film are more ideal.

A. These films have lower permeability to oxygen and hence may not be suitable.

Q. Any idea on the type of adhesive used on LDPE film?

A. No.

Q. Cling films are much used in Europe for sandwich packaging etc. Is it possible to supply a material like waxed paper, but is transparent? Also, indicate the cost and yield of the film. (K. Vishwanathan, Jardine Henderson Ltd., Calcutta)

A. No, such material is not available at present. The cost at present for the film is Rs. 50 per kg and the yeild being 42.6 m^2 per kg for 25 micron film thickness.

Q. Is the wax emulsion on Fruits and Vegetables being patented by CFTRI?

A. Yes.

Q. Have you tried MM HDPE film? (T. K. Srinivasa Gopal, CIFT, Cochin)

A. No.

Q. At what stage of fruit (raw or ripened) this expt. was carried out? And what was the impact on the natural taste & freshness of orange and apples? (R. N. Deshpande, Voltas Ltd, Bombay).

A. It had optimum stage of maturity and it retained the original taste and freshness.

Paper 4: Nylon-6 film— A revolution in the Packaging industry—*by Mr. V. S. Munge.*

Q. Are nylon films available in India? What is the lowest gauge you can go down to? (K. Vishwanathan, Jardine Henderson Ltd Calcutta).

A. Yes, nylon films are being manufactured by three firms. Generally, nylon films are available in the lowest thickness of 25 micron, and it will go down to 10 micron shortly. In the bi-axially oriented form, 6 micron film could be made.

Q. What is the adhesive used for nylon laminations?

A. Polyurethane based adhesives are used.

Q. Nylon being hydrophilic, does it exhibit high permeability to gases at high humidities? (P. Veerraju, PC, PTD, CFTRI).

A. No.

Q. What is the cost of nylon film? (H. B. N. Murthy)

A. It is about Rs. 85 per kg. Further, it is Rs. 2 per sq. m. of 25 micron film.

Q. LD & HDPE films are coated with Saran to reduce gas permeability. Is nylon film also coated with Saran? (Dr. S. S. Arya, DFRL)

A. Saran is best, but very costly. Saran coated nylon is not being currently used to pack oils.

Q. Can metallized nylon be used in place of metallised polyester? (Dr. N. Balasubramanyam, CFTRI)

A. Initial work has been done on the metallisation of nylon and the process should be commercialized.

Paper 5: Aluminium in Packaging industry—*D. N. Gangadhar, Klas Engineering Co.*

Comment: As against what was mentioned by Mr. Gangadhar, tinplate installed capacity in India is not 80,000 tonnes but 300,000 tonnes. *(Kumaraswamy, Tinplate Co., of India Ltd.)*

Q. What is the status and cost of energy, vis-a-vis Aluminium in the present context? (K. Vishwanathan, Jardine Henderson Ltd)

A. Compared to tinplate, aluminium is costlier at present. But since aluminium containers could be made in thinner gauges, they may prove economical.

Q. Ground coffee is vacuum packed on a large scale in Western countries. How does the evolution of gases from coffee affect vacuum packing? (Vijay Toley, Rollatainers Ltd, Faridabad).

A. It is preferable to pack coffee powder up to the brim with as little of headspace as possible.

Q. To what extent is aluminium recycled, i. e. used aluminium containers? (Major NVR Iyengar, Bangalore).

A. At present it is not much in our country. The current cost of aluminium is Rs. 24-28 per kg, and on recycling may come down to Rs. 16 per kg.

Q. Can aluminium container be used for packing fish products? (Ms. Satyavathi, RRL, Trivandrum)

A. They can be used, provided they are lacquered.

Paper 6: Co-extrusions in Food packaging *by S. Chidambar, XPRO India Ltd., Delhi.*

Q. What are the major food items packed in co-extruded film? (K. Vishwanathan, Jardine-Henderson Ltd).

A. Co-extrusion is done for two main reasons. It is cost effective to replace the existing laminates and to adopt new systems. They are used to pack wine, beer etc.

Q. Can we use polyester/PP Coextrusion for heat sterilizable pouches (N. Balasubramanyam, CFTRI, Mysore)?

A. Polyamide/PP etc. are commercially available now. Polyster/PP has to be made in due course.

Q. Where are Co-extruded plastic bottles used? (HBN Murthy' Bangalore)

A. They are mostly used in Europe to pack food items like sauces & fruit juices.

SYMPOSIUM SESSIONS

SESSION II—PACKAGING METHODS & PERFORMANCE

Chairman: Sri. U. D. Laad
Co-Chairman: Dr. N. Balasubramanyam

Rapporteurs: Mrs. R. V. Gowramma
Sri. Radhakrishnaiah Setty

Recent Developments in Food Packaging — Aseptic Packaging

S. N. PRAHLAD
Wimco Limited Bombay

ABSTRACT

The definition and the basic objectives of aseptic packaging have been mentioned. Several levels of asepticity such as commercial stability, enzyme inactivation and quasi aseptic have been briefly discussed. The present practice adopted by the food processing industry has been reviewed. The limitations for packing tropical fruits, purees and concentrates and the steps to be taken are indicated.

Aseptic Packaging has evolved from the European process for packing mllk and other drinks to total technology for many products. The aseptic movement has reached far beyond the packaging equipments and its impact is booming worldwide. Affected areas are the packaging materials, processing equipments, ineredients and even food colours. It appears that the conventional processes in the food manufacturing system need to bo altered for it.

Aseptic packaging system has been in Europe for decades and has progressed steadily. Now, the United States has entered the arena and this has set off tremors through the entire food and beverage industry of the United States. You can call it 'contagious'. This has also affected back and regenerated European interest in aseptic technology. For both users and suppliers, the market is a massive one.

Let me mention that for the dairy industry the aseptic process has proven a life saver. It has reawakened the consumer interest in the dairy products in Europe and also encouraged companies to develop new products.

What Exactly is 'Aseptic'?

Aseptic Packaging is the Independent Sterilization of Product and Packaging and then Assembling the two in a Sterile Environment.

The basic objective is to sterilise the product in a manner that minimizes thermal damage to the product and thus provides higher quality product than would otherwise be available from other processes.

Another basic objective is to sterilize the packaging by means that reduce the time-temperature experience of the material and permit the employment of materials less expensive and of lighter weight than traditional metal cans and glass jars.

There are several levels of ASEPTICITY.

Commercial Sterility

In aseptic packaging of foods the concept of commercial sterility is necessary and has to be accepted by technical and regulatory authorities. Commercial sterility means the absence of micro-organisms-of public health significance—and also which can cause spoilage or economic damage in normal distribution.

Enzyme Inactivation

It is still not included in any definition of commercial sterility in aseptic packaging. They are enzymes-biological catalysts present in almost all food products.

Commercial sterilization processes must take account of the need to destory enzymes that would otherwise accelerate biochemical deterioration—such as oxidation, browning, nutrient and flavor losses, textural breakdowns, etc.

Quasi Aseptic

There is also the possibility for the processor to merely reach a degree just below total asepticity. In this concept, products may still have to be refrigerated in order to achieve longer shelf life.

It is said studies are yet to be conducted in depth on many of the complex interacting variables of aseptic packaging in relation to sterilization methods.

To site a few, there are many varieties of sterilisation methods employed:

—Hydrogen peroxide, at a variety of concentrations and temperatures

—Hot air

—Steam

—Superheated steam

—Quarternary ammonium compounds

—Plasma discharge

—Ethylene oxide

etc.

Aseptic Packaging for Tropical Fruit Pulps and Concentrates

Aseptic packaging of dairy products and fruit juices in consumer packs has been well established in the western world. Packaging in paper containers, plastic containers, etc. has already been extensively used in the European markets.

The new concept of packaging aseptically in bulk fruit purees and concentrates is required for reconversion into consumer packs and prepare one's own 'brand name' products at different locations, both in domestic markets and in export markets.

For centuries varieties of methods have been used for packaging fruits, the latest method being dehydration. In the latter half of the 18th century pasteurisation in tins and jars was introduced. This had its own limitations. The desire to improve upon this led to the development of sterile storage. The word 'ASEPTIC' is becoming wellknown, where all the undesired microorganisms are removed while still retaining the natural qualities of fresh products as far as possible.

How Does Aseptic Systems Work?

In the aseptic installation the fruit is processed to puree or juice in the normal way. The remaining oxygen, which is responsible for oxidation, a process which causes loss of colour, flavour and taste, is removed in vacuum.

The oxygen-free product is heated for a very short period in a closed system to 85°C and speedily cooled to approximately 20°—25°C.

As a result of the short heating followed by rapid cooling, the aroma, flavour and colour losses are minimised.

The next process is filling and for this purpose bags with plastic lining, an aluminium middle layer (or a metallic middle layer) and plastic outer is used. This system has been developed to keep oxygen penetration to minimum. Sterile bags are filled by fully automatic machine after nitrogen has been introduced into the bags to prevent oxygen from getting in.

Aseptic packaging in bulk can be done in bags of 5 kgs, 20 kgs and 220 kgs. However, convenience of handling, transportation, shipping, etc. is to be considered.

The size of bulk packages has to be compared in relation to traditional packaging used, i. e. cans of sizes 3.1 kg or 5 kg.

Opening a 20 kg bag takes less time than four or five cans, apart from solving disposal problems.

There are equipments which could be used for tipping the bag-in-drums straight on to the tanks, or, the product can be pumped, under aseptic conditions, from the drums.

The aseptic packaging technique is passing through a period of considerable growth. It is considered as the packaging system of the future. Considerable research is being undertaken on the type of packaging material; aseptic packaging under tropical conditions for tropical fruit purees and concentrates. The technology is new.

The Government of India has already recognised the aseptic packaging system of packaging fruit purees and concentrates and has liberalised the import policy on import of this sophisticated high technology. Under this program few installations have been established in India. This signifies the beginning of processed food industry in India.

Limitations

For packing of tropical fruit purees and concentrates, following steps are to be taken:

1. The industries and research institutes like, CFTRI, should conduct experiments on the shelf life of the product against high ambient temperature,

particularly, for purees and concentrates of mango, guava and banana.

2. The packaging material being used under European conditions would not be ideally suited to Indian tropical climate. Experiments are being conducted by the packaging material manufacturers to obtain 'NIL' oxygen permeability material.

The present specification available is as follows:

Inner layer—1 ply of 4 mil EVA Polyethylene

Outer layer—1 ply of 3.8 mil lo-ox metallized barrier film

Aseptically packed material—bag-in-drums & bag in-boxes cannot be used unless containerisation made available and material is properly handled the ports. There are very stringent procedures to b followed in order not to damage the bags as th results in spoilage of products.

I give below a table which gives an indicatio of the product presently packed aseptically worl wide and anticipated growth by the year 198

This technology is going to make a total chang in the processed foods industry. The industry a well as the research institutions should study th new technology in depth and adopt this to th conditions here.

Table 1. Products being packaged in 'Aseptic' Packages Worldwide

Dairy	Fruit Based	Alcoholic	Other
fermented milk	Papaya drink	Saki	Sugarcane
yoghurt	Wintermelon drink	Wine	Lemon juice
yoghurt drink	mango, guava	*Syrups*	Isotonic
eggnog, custard	fruit soup	Mixed fruit	Herbal tea
pudding, ice	nectars		Lemon tea
cream mix, non-	*Sauces*	*Soy based*	Corn oil
dairy whitener	Catsup	soy drink	tomato
shipping cream	soy	soy milk	juice
Whipping cream	Bechamal		Coffee
substitute	chocolate		Chrysanthemum tea
Process cheese spread,			Jasmine tea
Dietary supplement			Water

Table 2. Market for aseptic and related packages 1987

Single Strength Fruit-Based Beverages	..	2,000	million packages
Juice Concentrates	..	200	,, ,,
Fluid Milk	..	1,000	,, ,,
Other Dairy Products	..	300	,, ,,
Pudding	..	50	,, ,,
Tomato Products	..	100	,, ,,
Other products	..	200	,, ,,
Total	..	3,850	(U.S.A.)

Table 3. Shelf life of products in months

Product	Orange & Mandarine			Grape Fruit			Lemon		Tomato	
Storage Temp.°C	Juice & Cells	Commi-nuted	Conc.	Juice & Cells	Commi-nuted	Conc.	Commi-nuted	Conc.	Comm.	Conc.
0°	12	12	12	12	12	9	12	6	18	18
10°	7	9	6	7	8	4	7	3	15	15
20°	4	6	3	4	5	2	5	2	12	12
25°	3	4	2	3	3	1	3	1	10	12

On Some Corrosion Factors in Canned Foods

P. MARSAL

French Tinplate Research Centre, 57 Thionville (France)

ABSTRACT

—nitrates brought by water or found in the product—oxgen in headspace —pesticides (dithiocarbamates)—storage tempetature mainly in the case of tomato based products.

As far as the two first are concerned, the can size influence is prominent.

Against these corrosion factors, the lacquering solution appears to be the most convenient, but there are some requirements and limits. The success or failure depends mainly on the porosity (scratches) of the lacquers used.

As a result of the large number and diversity of the food products now canned, many different requirements arise for qualities of cans. None of the available classes of can is suitable for all the foods that may be canned.

The prime purpose of packing in a metal container is the physical and chemical protection of the product to be marketed. For this, the main basic properties needed by the container are mechanical strength and resistance to corrosion for which both container material and the intended contents are relevant.

The two partners, tinplate and food product that together make a can of food, must match one another. Although the properties available for tinplate are well-defined and measurable, this is far from true for the foodstuffs that may be canned so that, in practice, the selection of the quality of tinplate best fitted for its purpose often presents problems. This selection may be affected by the conditions applying to canning and to storage, the period for which the canned product has to be preserved satisfactorily, the product aggressiveness, the limits on the transfer of metal to product, the need to maintain colour and flavour and many other special factors.

In this paper we will point out some corrosion factors, the first two of which can find their importance more or less increased with plain can size:

—nitrates brought by water or found in the product

—oxygen in head space

—pesticides

—storing temperature with the practical case of tomato based products.

Internal lacquering of cans is, undoubtedly the best way to impart chemical inertness to cans. But this way has its own limits and demands.

1. Can size Influence on Corrosion Resistance

The operation of the tin-iron couple for a tinplate can is schematized in Fig. 1.

Tin is the sacrificial (soluble) anode while iron is cathodically protected. That is the reason why tin coating thickness is usually the main specification for tinplate. The tin thickness determines, in principle, can shelf life but all can sizes do not produce similar corrosion results.

For the same tin coating, small can sizes have a much bigger tin anode per volume unit than large cans as shown in table. 1.

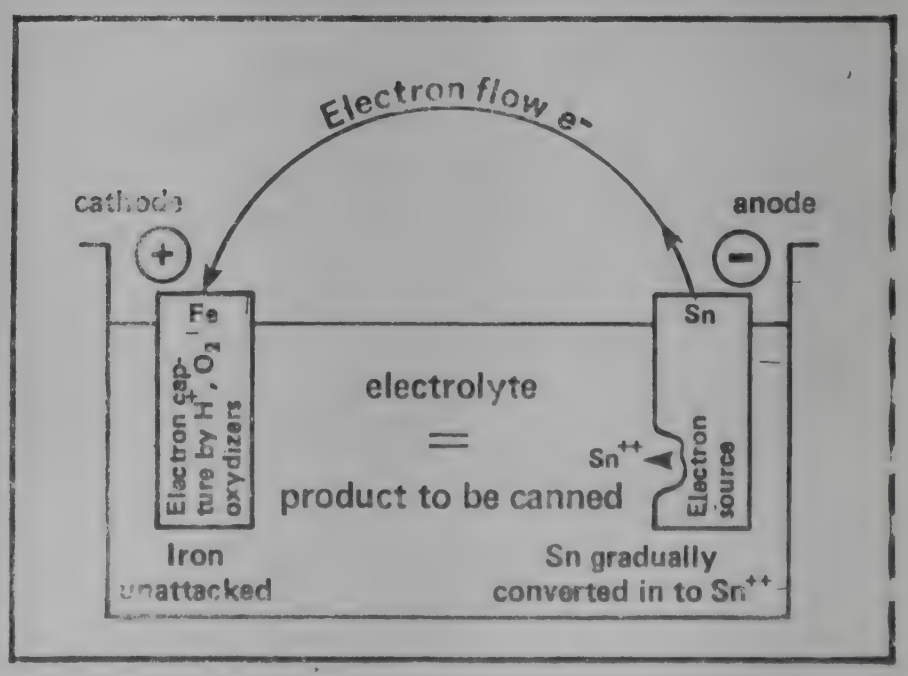


Figure 1. Schematic diagram of tin-iron cell. Importance and scope of tin coating.

Can size (*) Capacity ml	Diameter mm	Height mm	Surface of 2 ends cm²	Body surface cm²	Total surface cm³	% of can ends surface	Ratio Volume/surface cm³/cm² Plain ends	Lacquered ends	Tin concentration in product (mg/kg) after complete detinning for E 11.2 Plain ends	Lacquered ends
4 250	154	246	370	1 180	1 550	24	2.7	3.6	400	320
850	99	118	158	370	528	30	1.6	2.2	700	480
425	73	109,5	80	260	340	24	1.3	1.6	900	680
142	55	68	80	87	177	48	0.8	1.6	1 300	700
71	55	37,5	48	56	104	46	0.7	1.3	1 600	900

Table 1. (from 1976 CRFB Bulletin) Detinning of tin plate cans. Influence of can size.

For a 11.2 g/m² coating, complete detinning was observed with 5 liter cans with lacquered ends with tin at 320 mg/kg in the product, while partial detinning was observed (a third of total tin) for a small (71 ml) can with the same tin concentration in the product. This table needs no more comments, the results being so marked.

Can size influence is pre-eminent in presence of nitrates or oxygen, two corrosion factors which were the subject of many papers.

(a) The Role of Nitrates

Whether they originate from filling or dilution liquid or from the fruit or vegetable, nitrates detinning action becomes more marked as product pH is lower (figs 2 and 3).

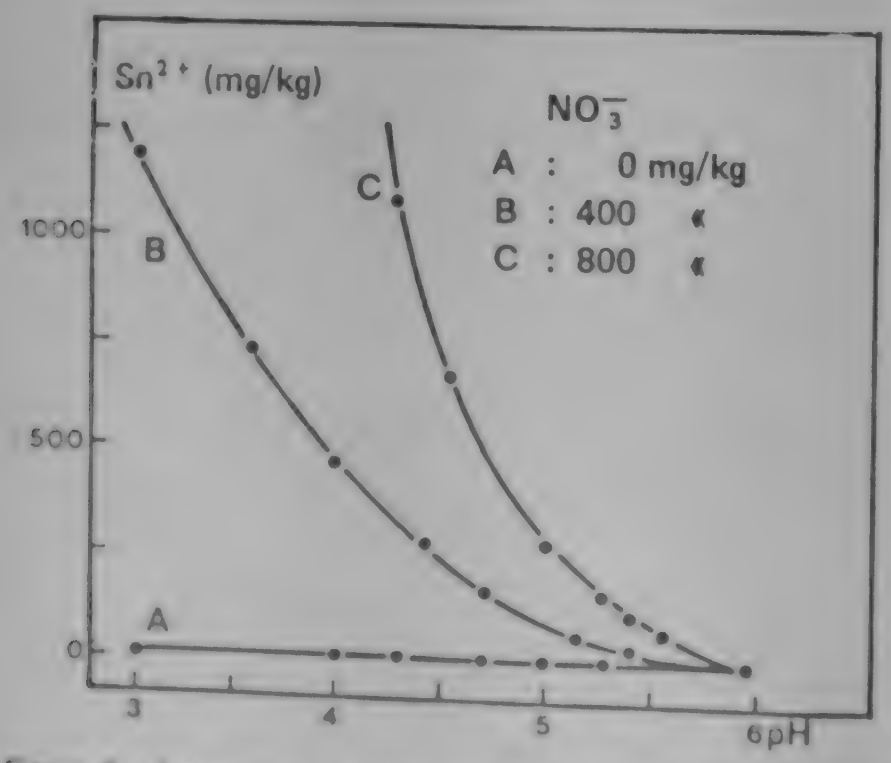


Figure 2 (according to STRODTZ and HENRY) Influence of pH on tin dissolution for various concentration levels in nitrates.

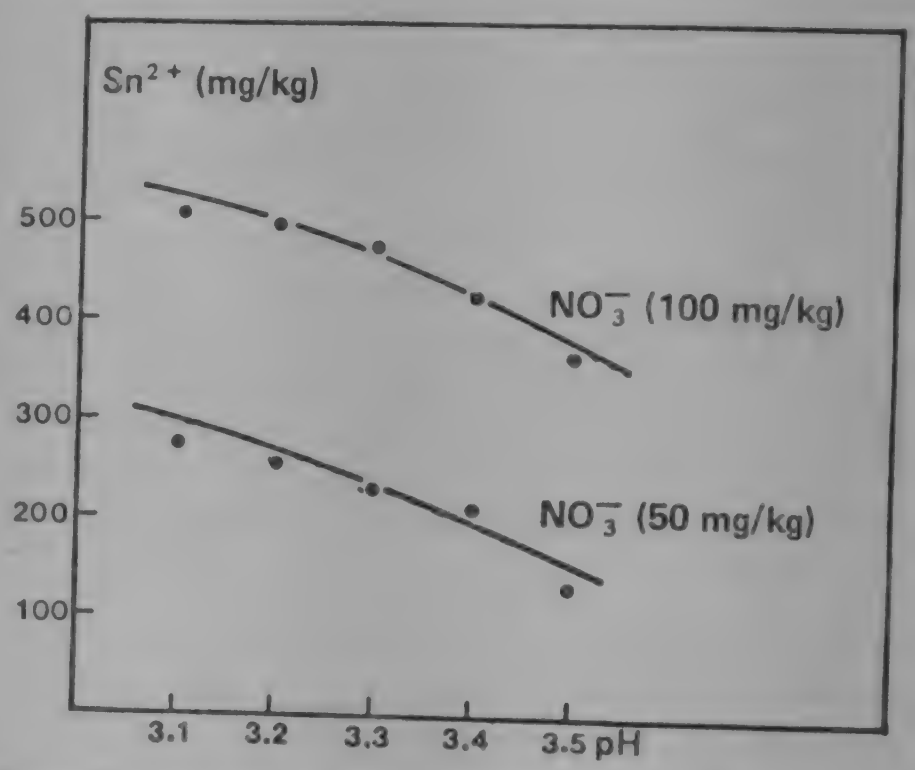


Figure 3. Influence of small variations of pH on tinplate corrosion through the presence of nitrates. (according to CRFB)

It often appears that detinning in the critical pH zone is proportional to the initial nitrate content, under the obvious condition that enough metallic tin is available inside the can (fig. 4).

Detinning influence of nitrates can be increased by catalytic ions such as Fe^{2+} (fig. 5) or promoters such as O_2 (fig. 6).

In model solutions, nitrates can be reduced to ammonium ions. Theoretically detinning should proceed without swelling (without hydrogen evolution) as long as nitrates remain.

Detinning speed is nearly independent of tin coating thickness and steel base composition (fig. 7).

It is quite easy, in canning plants to obtain a semi-quantitative measurement of the nitrate content

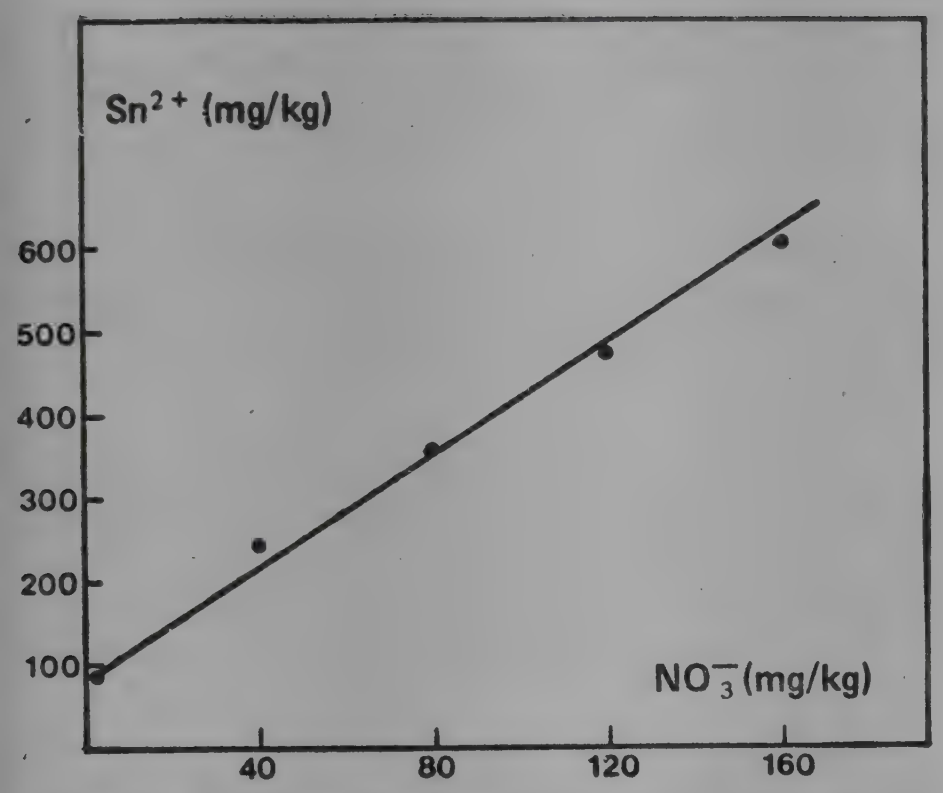


Figure 4. Relationship between NO^{-}_{3} content and detinning (after a 15 day storage at 37° C and pH : 3.5. (according to CRFB).

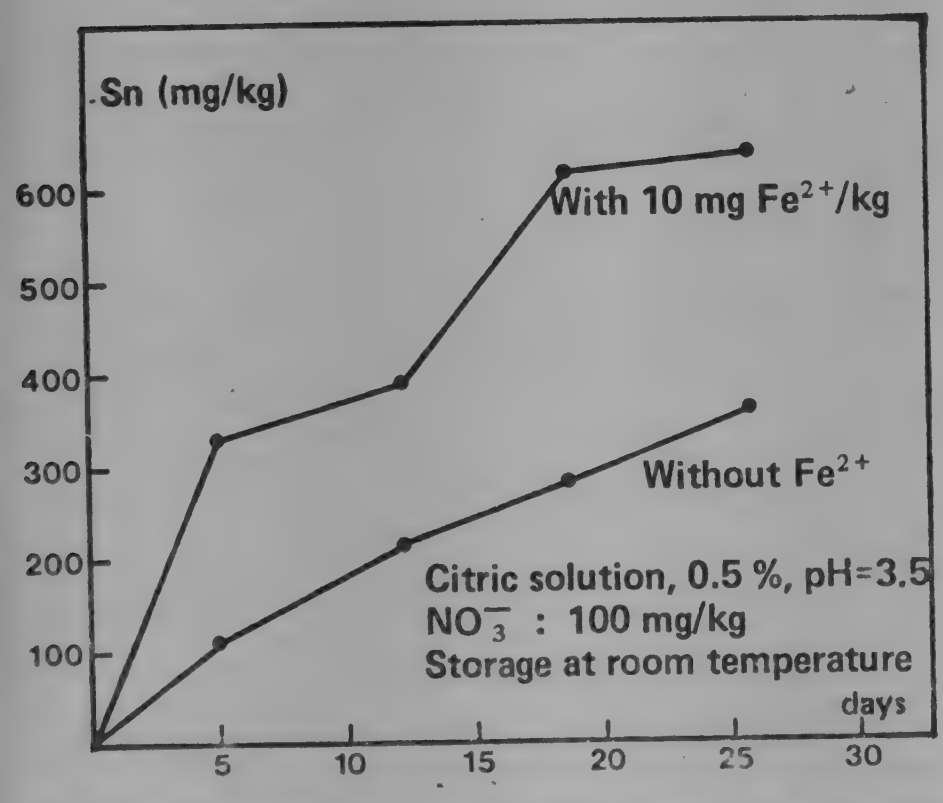


Figure 5. Catalytic influence of Fe^{++} ions on the corrosion of tinplate by nitrates (Tests of CRFB).

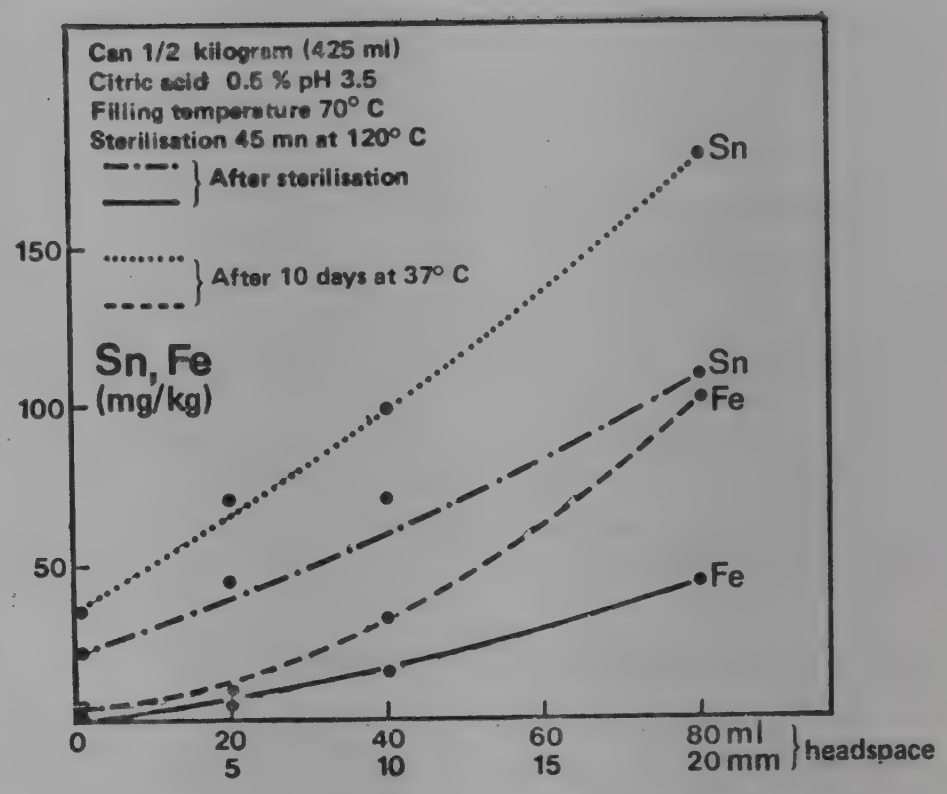


Figure 6. (from CRFB)) : Influence of oxygen in headspace on corrosion.

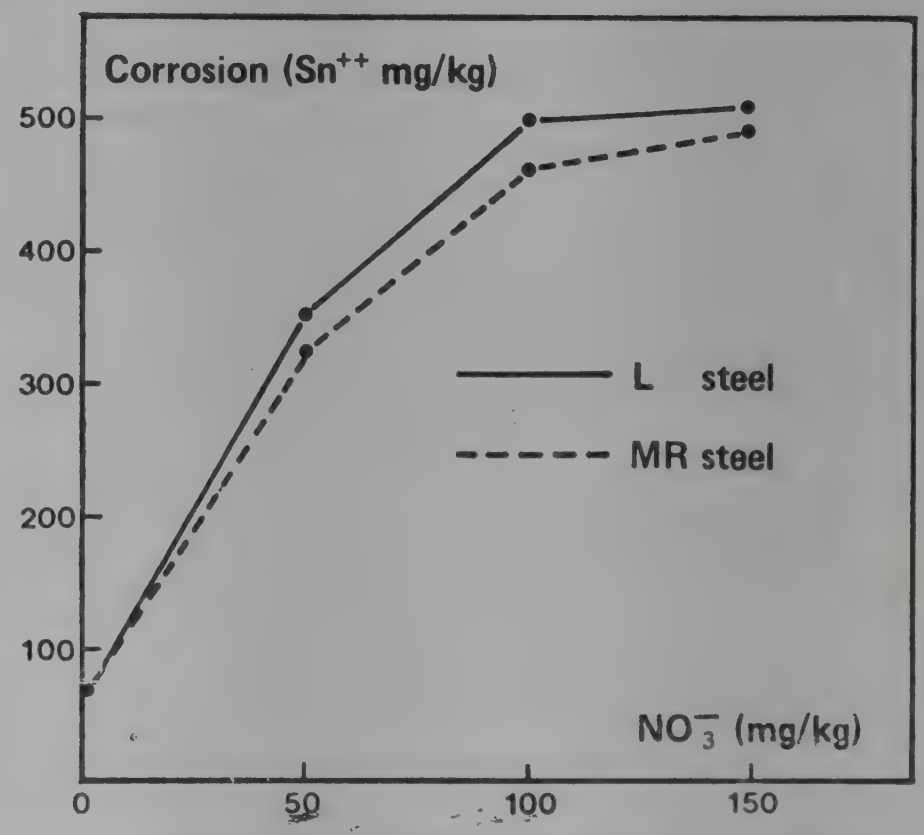


Figure 7. (According to CRFB): influence of nitrates in a citric solution pH: 3.3) on corrosion of E 11.2 tinplate after a 8 day storage at 37°C.

of the filling water or syrup through test sticks (*), for example, if the need to modify the water supply of the plant arises.

(b) The Role of Oxygen

Oxygen is the pre-eminent foe for the can and the organoleptic quality of the product. In figure 8, we can see the need of deaeration and of reduction of head space. Corrosion, thus, can be reduced easily through reduction of oxygen content in the head space.

As an example, oxygen in 5 mm head space in a kilogram can (850 ml) filled at 70°C (that is about 6 ml of oxygen) is able to oxidise 60 to 70 mg tin, that is a third of an E 5.6 tin coating.

(c) Nitrates and Head Space Oxygen

With the two above corrosion factors we can look at the influence of can size. Table 9 shows calculations for three examples:

(*) Test sticks "Merckoquant nitrat test, Merck in DARMSTRADT (FRG)".

Chosen values:

—nitrate content of product: 40 mg/kg
—filling at 70°C with 5 mm head space
—product (vegetable or fruit) pH 4.5
—tin coating E 11.2 with lacquered ends.

The results in Table 2 show that the 5 kilogram can (4 250 ml) has got a sufficient tin coating to withstand corrosion; detinning will be complete. Under the same conditions, the half kilogram (425 ml) can size will have 4.6 g/m² of residual tin to withstand normal corrosion.

2. The Influence of Pesticides

In this paper, we do not intend to criticize the use of pesticides. They are beneficial for protection of crops and increase of yield. The different treatments (washing, scraping, peeling and blanching) applied to fruits and vegetables before canning and sterilization contribute to eliminate the most important part of pesticide residues.

Their amount, while generally small, in some cases however, can affect the behaviour of a can which is sometimes more sensitive than the consumer.

The nature of pesticides can vary widely, so their effects on corrosion are complex. Some are inhibitors rather than accelerators of corrosion at high dosage. Others become very aggressive even at trace levels (1 mg/kg after thermal treatment of sterilization).

Although all sulfur based products (colloidal sulphur, sulphur oxides) may cause sulfurization

Table 2. The following equivalences were used: 1 ml O_2 for 10.6 mg Sn
1 mg NO^-_3 for 7.6 mg. Sn

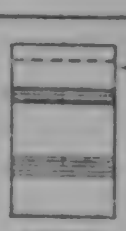
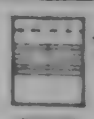
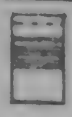
Size \ Sn	Total usable tin in can from internal coating	Tin dissolved by O^2 mg	Tin dissolved by NO^-_3 mg	Total dissolved tin mg	Tin coating remaining for normal corrosion
4 250 ml 	1 360	150	1 300	1 450	Total detinning
850 ml 	410	60	260	320	2.4 g/m²
425 ml 	290	40	130	170	4.6 g/m²

Table 3. (from CRFB: Influence of dithiocabramates on corrosion of tinplate cans.
Concentration: 1 mg/kg after 90 storage days at 37°C.

Type	Can	(bar) 1 bar = 10^5 Pa	Sn mg/kg	Fe mg/kg
No addition	Plain	− 0.50	15	3
	Lacquered	− 0.50	3	3
Dithiocarbamate L	Plain	− 0.40	40	10
	Lacquered	− 0.10	3	54
M	Plain	− 0.50	30	3
	Lacquered	− 0.25	1	19
N	Plain	− 0.55	30	8
	Lacquered	− 0.05	5	58
O	Plain	− 0.50	25	2
	Lacquered	− 0.15	2	53

and detinning, we will only see the role of dithiocarbamates which exhibit a particular aggresivity against iron which end therefore in swelling or piercing of can.

In Table 3, it can be seen that in lacquered cans, the four tested dithiocarbamates modify, even at the very low level of 1 mg/kg, the behavior of tin/iron couple.

The iron through the discontinuities of the lacquer and tin layers, is corroded through pitting.

Figures 8 and 9 illustrate the influence of dithio-

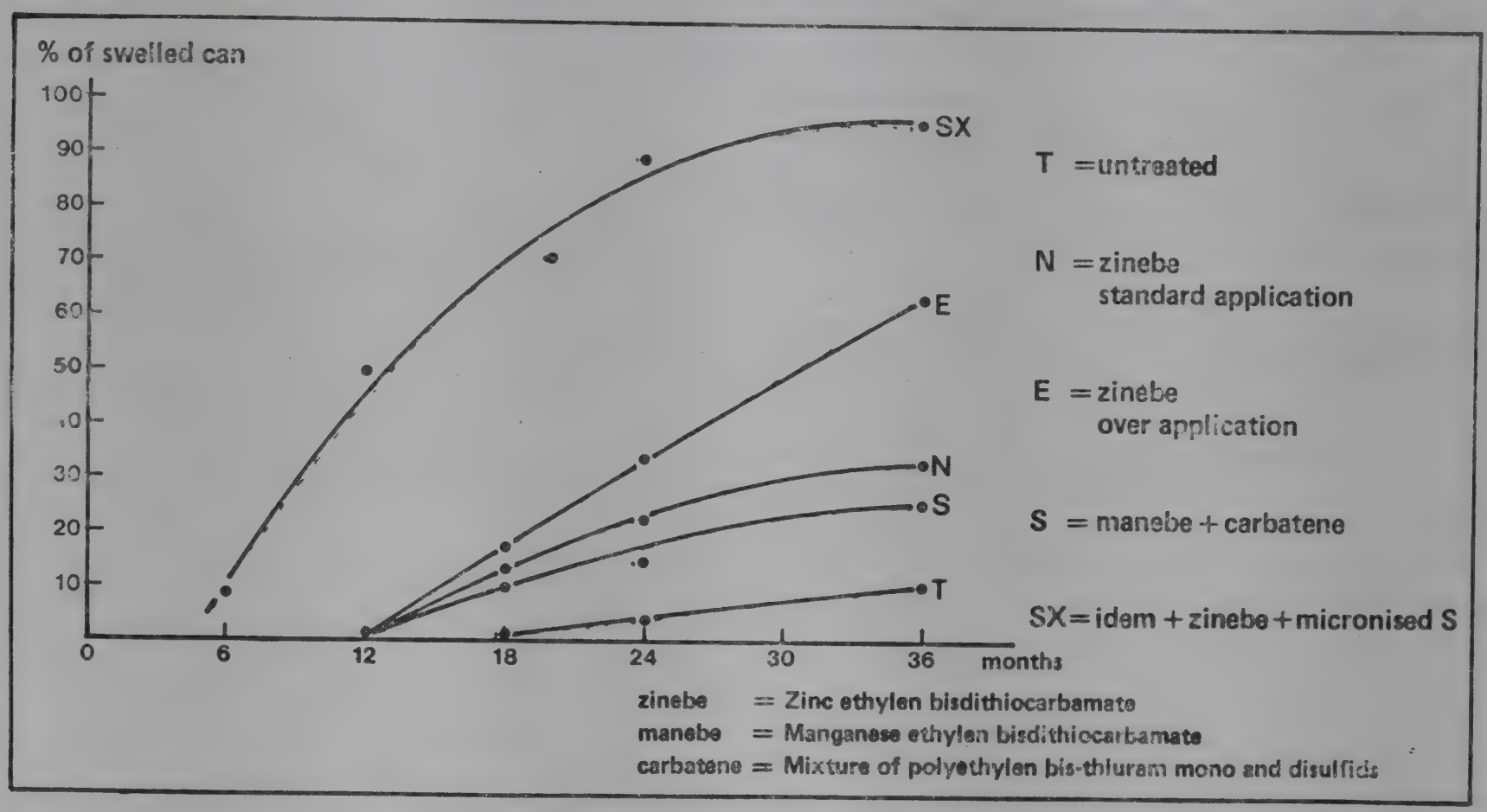


Figure 8. (from R. Allouf, G. Jarillon, J. Calas) (5): Influence of antifungus treatments on apricot cans corrosion.

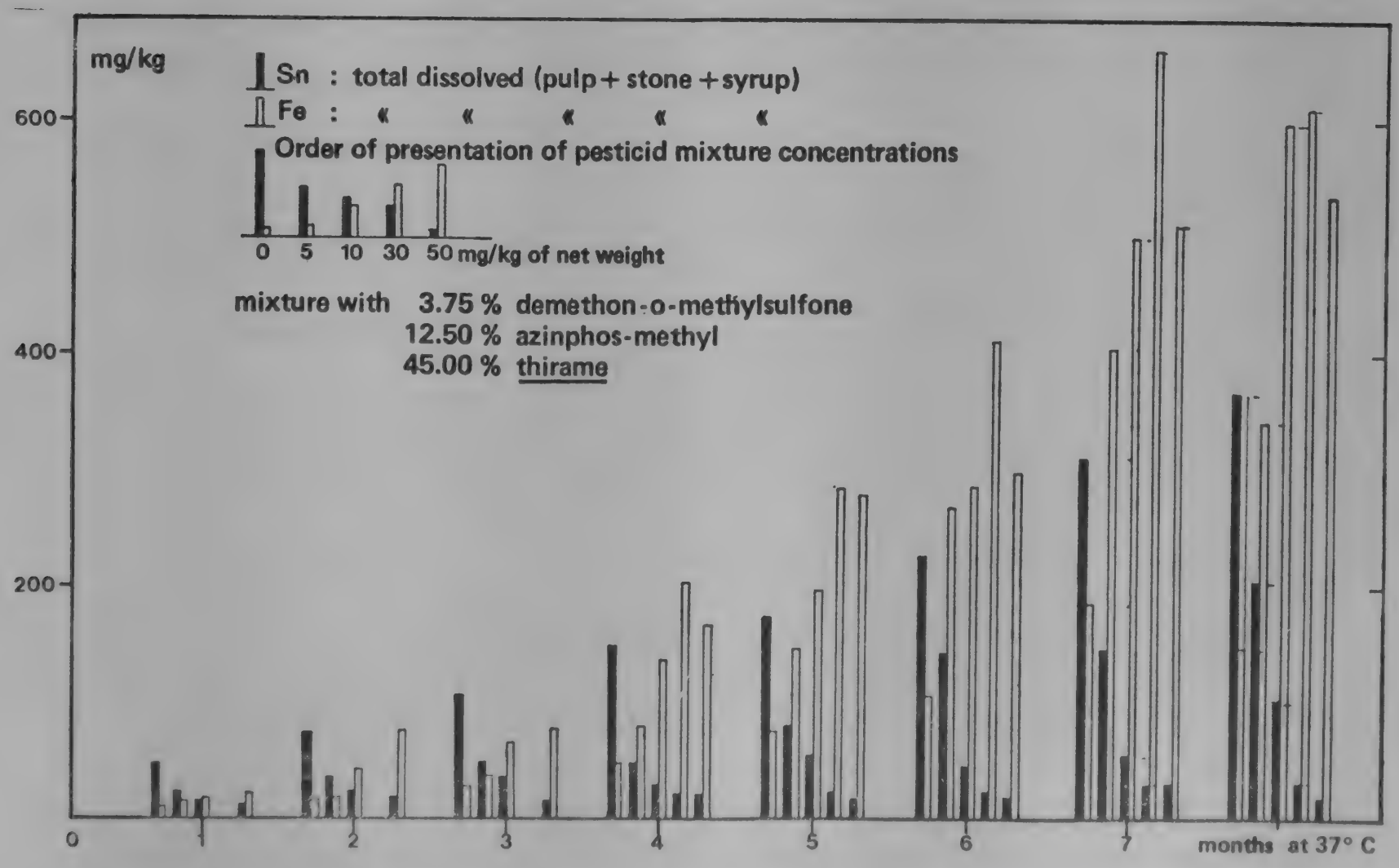


Figure 9. (from CRFB): Influence of pesticide products on plain tinplate corrosion by mirabelle plums.

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carbamates on the behaviour of unlacquered tinplate fruit cans. For apricots, the percentage of swelled cans rises rapidly with storage duration and with the pesticide treatment level before cropping. With mirabelle plums in syrup, we observed that preferential dissolution of iron increased with time and with the amount of pesticide (including dithiocarbamate thirame) introduced in the can.

We must keep in mind that traces of degradation products of dithiocarbamate based pesticides are aggressive against iron. This deleterious influence, already notable on plain cans, is heavily increased in lacquered cans.

3. Influence of Storing Temperature. Case of tomato based products (concentrate and juice)

A general approximate rule indicates that an increase of storing temperature of 10°C doubles the rate of chemical reactions and, in particular, corrosion reactions. From this rule the shelf life of a can at 17°C would be about 4 times longer than at 37°C.

Of course this rule is only a rough approximation since the canned product is not a model solution. On the basis of data given by literature, and by our own experience, multiplication factors between shelf lives at room temperature (about 20°C) and 37°C would vary between 2.6 and 4.3 depending on the product nature.

Several different corrosion reactions can occur simultaneously and for the same overall system some elementary steps may be faster than others.

After a prolonged exposure to high temperature, corrosion sometimes "bolts" after an increase of aggressivity due to chemical or abiotic transformations of the product without interference from the can. This is the case of tomato based products and particularly of tomato concentrate.

Several papers were concerned with the aggressivity of tomato concentrates against tinplate either plain or lacquered. Overlooking corrosion factors such as variety or maturity level of tomatoes, the main corrosion factor was a long storage at too high temperatures.

On figures 10, 11, it can be seen that "brown index" or optical density of serum, hydroxy-methyl furfural (HMF) content and formation of CO_2 are

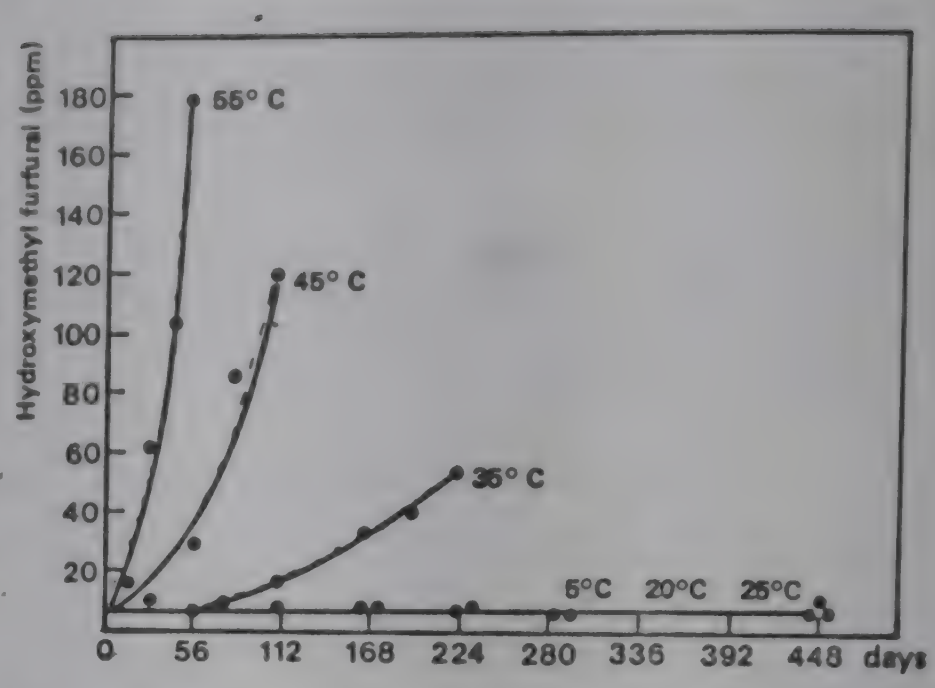

Figure 10. (from B. S. Luh. Sherman Leonard and G. L. Marsh) (7): Influence of storage temperature on tomato concentrate serum color.

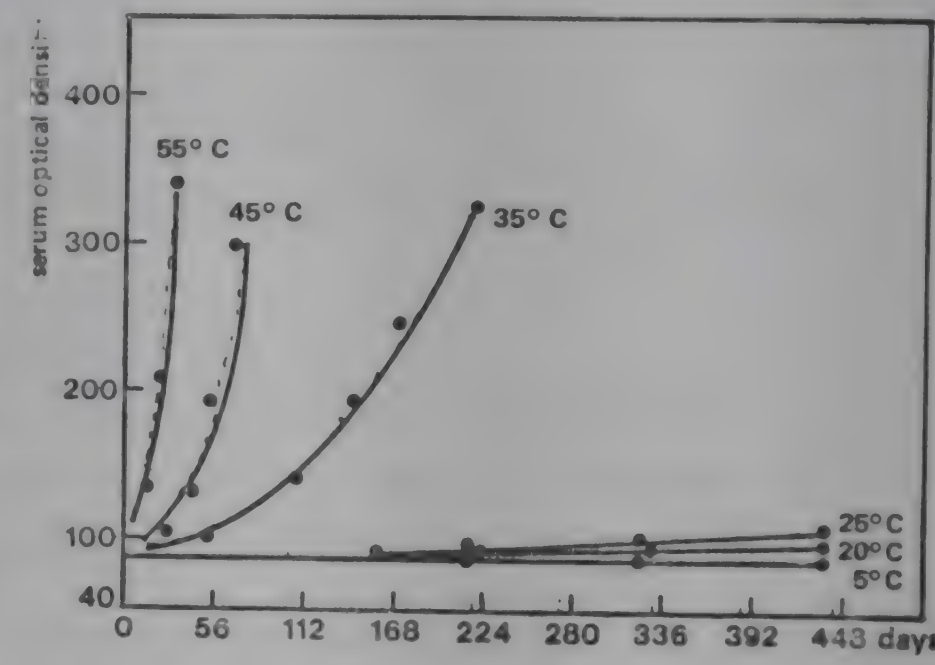

Figure 11. (from B. S. Luh, Sherman Leonard and G. L. Marsh) (7): Influence of storage temperature on hydroxymethyl furfural content of tomato concentrate.

analytical features linked to the non enzymatic browning. Therefore the fact that the can was submitted for too long a duration to too high temperatures cannot be doubted. A slow cooling after sterilization of large cans, for example, would have the same results.

Can corrosion is accelerated as seen in figure 12. There is a very good correlation between brown index and internal pressure (positive or negative) in cans. In our case, the cans were lacquered (1 layer of lacquer) before canmaking.

The most interesting point in the corrosion of lacquered tinplate cans of tomato concentrate, is the intersection of migration curves of iron and tin as seen in figure 13.

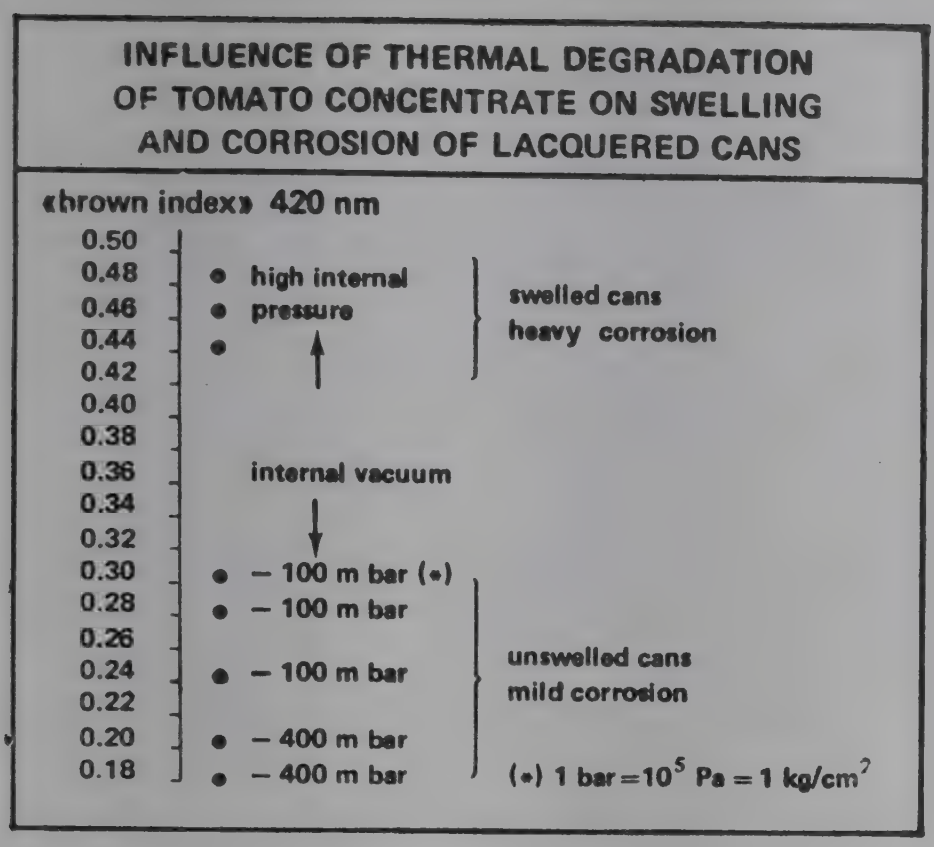

Figure 12.

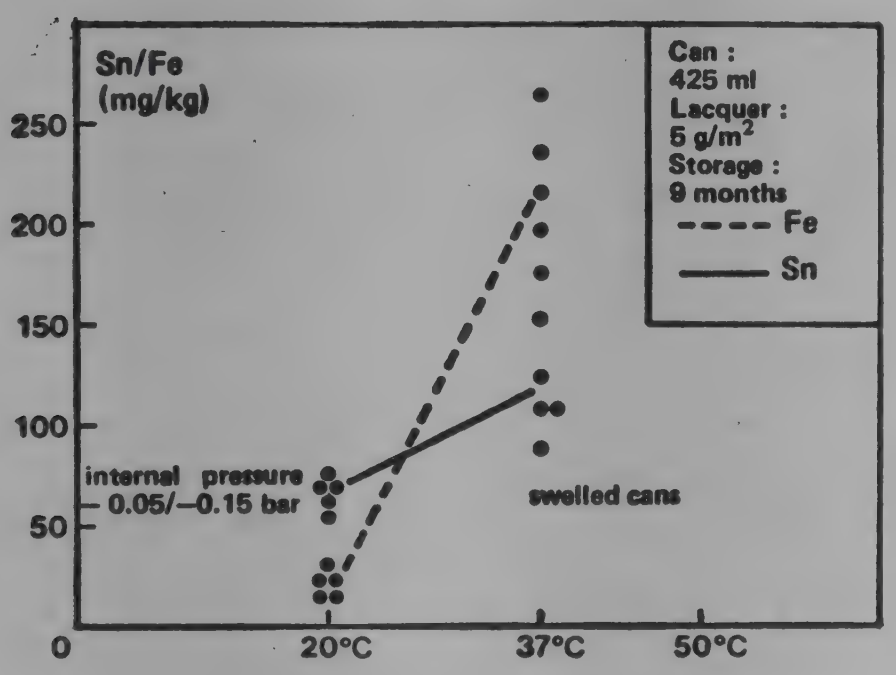

Figure 13. (from CRFB): Influence of storage temperature on lacquered cans corrosion by tomato concentrate.

For the same storage duration, that is 9 months, it can be seen that at 20°C corrosion is slow and takes place on tin while at 37°C cans swell with more iron than tin. From our point of view, some conclusions can be extracted from this observation. Tomato concentrate cans due to be exposed to high temperature must be carefully lacquered. This protection quality must be imparted by a heavy layer of lacquer (2 layers) to limit porosity or by a pigmented layer (aluminium or titanium oxide) to increase impermeability of the lacquer and to increase its resistance to abrasion and scratches. But the best organic coatings are unable to stop CO_2 evolution through thermal degradation as seen before. Can swelling could take place without any hydrogen evolution. (Table 4)

4. The Lacquering Solution. Its Limits and Requirements

Against the corrosion factors hitherto studied, some specific measures can be taken (decrease of nitrates content, hot filling with minimum head space, elimination of pesticides, storing at low or at least, moderate temperatures. But lacquering is the most suitable solution to protect can and product. It is, anyway, the only protection against rapid detinning by nitrates.

While lacquering is intended to improve can inertness, we must care to maintain a good ratio of quality to price and to adapt the quality level of the organic coating to the corrosion type expected and its severity.

With tinplate in contact with a great variety of products, lacquer porosity is not a problem for the can behavior, due to the good chemical inertness of tin under the lacquer and of its anodic behaviour.

Table 4.

THERMAL DEGRADATION OF TOMATO CONCENTRATE IN LACQUERED CANS
ANALYSIS OF GASES IN HEADSPACE (%) AFTER 1 YEAR STORAGE

H_2	61.8	79.5	74.3	74.9	18.3	45.6	50.0	12.1	14.6
O_2	0.2	0.1	0.1	0.1	0.8	0.3	0.2	1.5	1.1
N_2	9.2	4.5	7.1	5.6	61.9	22.2	17.3	76.8	75.1
CO_2	28.8	15.9	18.5	19.4	19.0	31.9	32.5	9.6	9.2
brown index	0.377	0.410	0.386	0.369	0.354	0.439	0.464	0.220	0.230
	← swelled cans →							← unswelled cans →	

Corrosion risks when they exist are of two different natures (Fig. 14 and 15).

Iron dissolution always takes place with hydrogen evolution and with an action on some organoleptic features such as, (the formation of greyish coloured tannins with iron complexes)

When these two types of corrosion are heavily marked, then, the organic protection should be reinforced prior to can manufacture by means of a double lacquering or by a lacquer pigment, to which a re-lacquering and or a side-seam lacquering after can manufacture can possibly be added.

The porosity or more precisely the number of pores depends on the thickness of lacquer coating. Whatever the measuring device used, it decreases exponentially with the thickness of the lacquer coating, as shown in figures 16 and 17.

It is obvious that after transformation of the lacquered material, as can ends or bodies, the number of pores and of scratches preferentially increases in some areas and these breaks of continuity lead to corrosion phenomena.

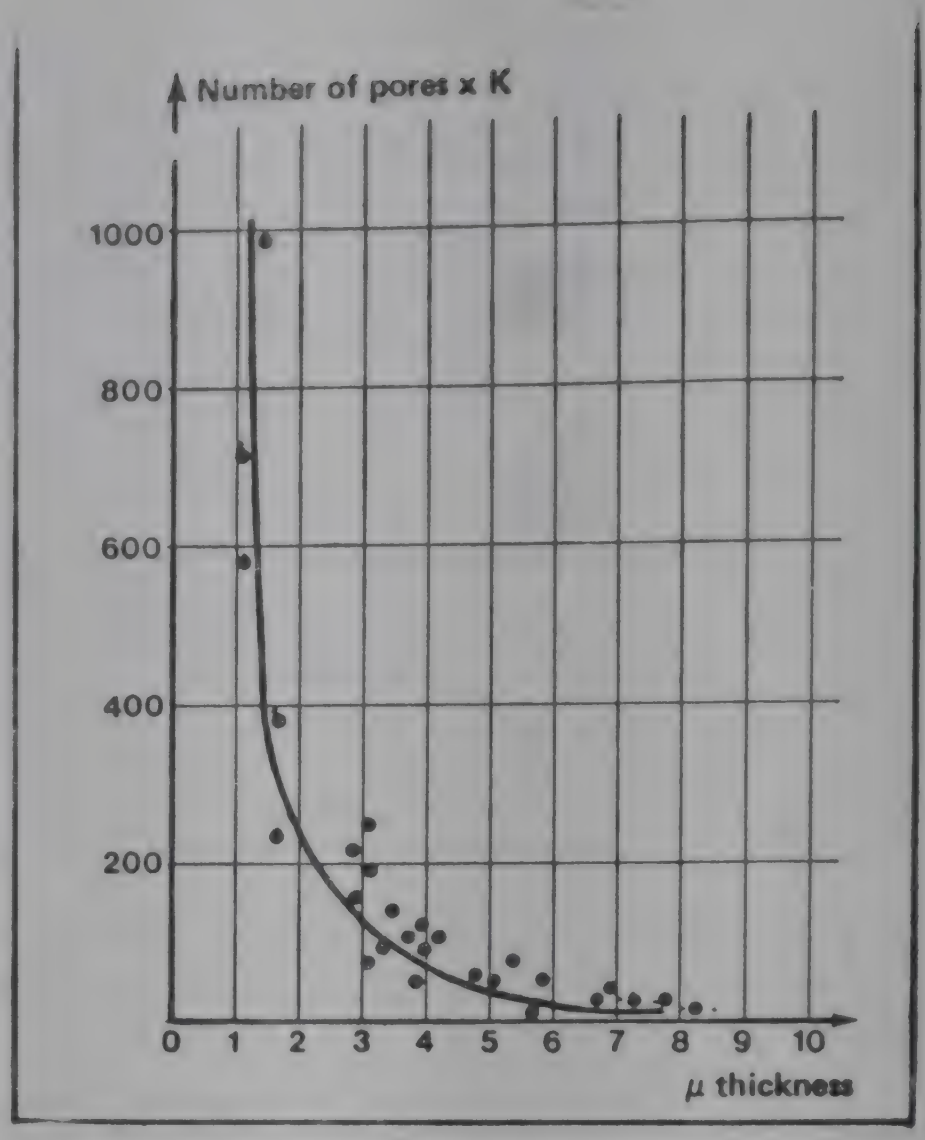

Figure 16. Measurement of pore number. (from CRFB test-Bulletin annual 1972).

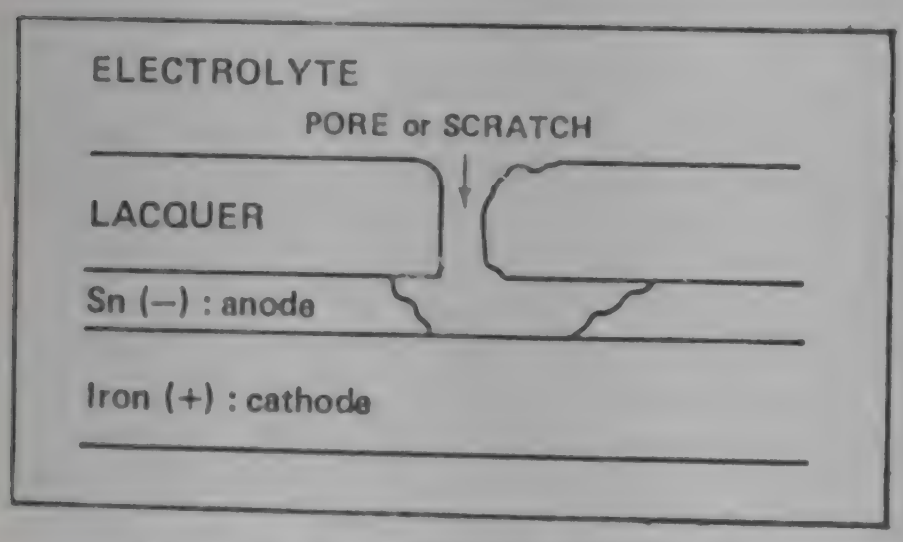

Figure 14. Corrosion under lacquer film.

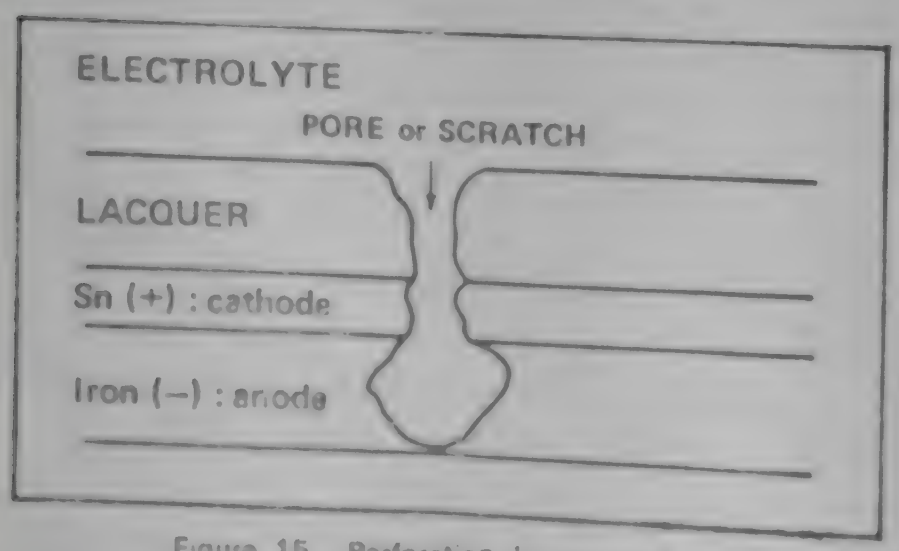

Figure 15. Perforation in progress

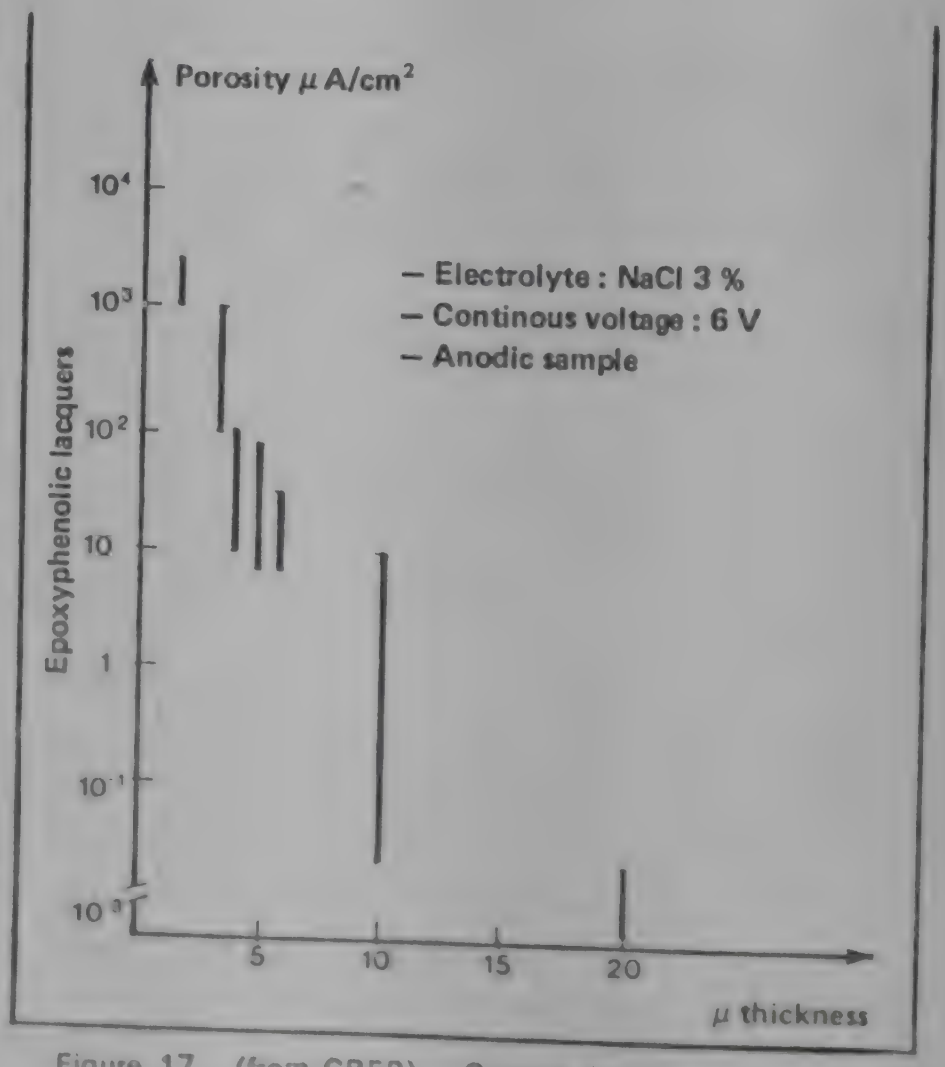

Figure 17. (from CRFB): Current density measurement.

Table 5

Family	Use	Flexibility	Adhesion	Resistance to sterilisation
Oleoresinous	Fruit and vegetable antisulfur lacquer if ZnO pigmented	poor	good	medium
Phenolic	Fruit, vegetable, meat, strong barrier effect	poor	poor	very good
Epoxyphenolic	Very wide use, fruit, vegetable, meat; may be pigmented with Al, ZnO, $ZnCO_3$	good depending of epoxy/phenolic ratio	good	good
Vinylic	Beverages (beer, carb. drinks)	excellent	good	good chemical resistance but unable to stand sterilisation temperature
Organosol	Very wide use for D.R.D. cans may be pigmented with Al, TiO_2	very good	very good	good even at sterilisation temperature
Acrylic	Pigmented with TiO_2 esteemed for their white look	good	good	medium
Epoxyurea	Beverages (tasteless)	good	good with good abrasion resistance	medium
Polyester	Pigmented with TiO_2	medium	good	good

In practice, the majority of the porosity measuring devices indicate a constancy or a shift of quality rather than the very quality level.

Apart from the porosity, there are of course other physical and chemical qualities peculiar to lacquer film that are to be considered. The families of organic coatings for the internal protection of metal packages are reduced to a small number. Table 5 shows their main characteristics to permit a selection.

Conclusion

At this point of our report, what is to be kept in mind? We have endeavoured to direct our comments on precise and actual observation. Even if it is reassuring to know that a technical solution exists for any corrosion problem, the difficulty lies in the knowledge of the problem to cope with. Of course it is easy to imagine and achieve a high quality can but there is still a requirement to keep within a reasonable quality/price ratio.

Some tables propose can types to be used with given products. Though these tables have an undeniable usefulness they nevertheless evidence some drawbacks:

—the recommendations of these tables should not be observed strictly: they cannot give a guarantee in all cases as to the characteristics of the products; the conditions of preparation and the marketing ways may vary from one food packer to another.

—these recommendations do not take into account either the constant progress of materials and cans—considering an improvement in quality of course—or the agricultural practices and those of food packing.

Therefore, only a cooperation between food-packer and can maker on one side and between the pack manufacturer and the metal producer on the other side can give the guarantee of a proper use of the different types of cans.

Literature

The number of papers published about various aspects of the behaviour of tinplate cans is so large that it is impractical to provide a complete list of them. We list here only the studies and papers from which we took a graph or table of results.

(1) STRODTZ N. H., HENRY R. E., The relation of nitrates in foods to tinplate container corrosion, *Fd. Technol.* Fev. 1954, *8,* (2) 93.

(2) Bulletin Annuel 1973 du Centre de Recherches du Fer Blanc

—Anomalies relevees au cours d'essais de corrosion du fer-blanc non verni par des mirabelles au sirop,

(3) Bulletin Annuel 1976 du Centre de Recherches du Fer Blanc

—Adaptation des fers-blancs aux produits a conserver,

(4) Bulletin Annuel 1977 du Centre de Recherches du Fer Blanc

—Le role des nitrates dans la corrosion du fer-blanc,

(5) ALLOUF R., JARILLON G. et CALAS J., Contribution a l'etude de la corrosion du fer-blanc par les abricots, Industries Alimentaires et Agricoles, 1977, 68

(6) Bulletin Annuel 1978 du Centre de Recherches du Fer Blanc

—Influence des produits phytosanitaires sur la corrosion des boites en fer-blanc,

(7) LUH B. S., SHERMAN Leonard and MARSH G. L, Objective criteria for storage changes in tomato paste, Fd. Techno. july 1958.

(8) Bulletin Annuel 1980 du Centre de Recherches du Fer Blanc

—Porosite des vernis epoxyphenoliques,

Performance Evaluation of Indigenously Available Packaging Materials for Retort Processing

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Defence Food Research Laboratory, Mysore-570 011

ABSTRACT

Indigenously available polypropylene film of thickness 60-75 μm has been found to be suitable for retort processing of Indian foods. Several modifications of the processing and handling operations have been standardised to suit the semimanual processing operations.

Many of the spectacular developments in science and technology have originated from military necessity which however have benefitted the common man subsequently.

The heat processing of foods in flexible films instead of the familiar metal can is the result of mainly the work carried out by US Army Laboratories at Natick due to the functional advantages of retort pouches for combat rations.

Importance of light weight flexible packaging to Service rations hardly requires any emphasis due to logistic advantages of the flexible materials. Difficulty of obtaining suitable can, in required number, has only further accelerated the need for alternate packaging system. Work in this country was hence started at DFRL, Mysore. Introduction of the new packaging system of heat processing in flexible materials for ready-to-eat Indian foods was however a difficult task. None of the special type of packaging materials given in Table 1 possessing the required properties were available in this country. (Table 2)

Table 1. Materials suitable for retort processing.

(1) 9-25 microns polyester/9-12 microns Al. foil/75 microns modified polypropylene.

(2) 12-12 micron polyester/9-25 micron Al. foil/P.E.-PP Copolymer.

(3) 15-30 micron polyamide/50-75 micron polypropylene.

(4) 12 micron polyester/9 micron Al. foil/15 micron polyamide/50 micron polypropylene.

(5) 50-75 micron polypropylene.

Table 2. Requirements of films

(1) Low O_2 permeability
(2) Low WVTR
(3) Temp. stability (0-150°C)
(4) Low hydroptulic properties
(5) Heat sealability
(6) Suitability for use with food
(7) Dimensional stability
(8) Physical and seal strength
(9) Good agency properties

Since most of the laminates available in the country are based on LD polyethylene, these materials suffered dintinct thermal damage and poor sealing characteristics. However, laminates with high density PE were evaluated due to the higher softening temperature of HDPE. But due to the basic weakness of sealing characteristics, the material did not prove to be reliable. Efforts to laminate imported polypropylene with aluminium foil also failed since the appropriate adhesive for the purpose was not indigeneously available.

By 1978, polypropylene film became indigeneously available with production of the polymer by IPCL, Baroda, Since the film made out of the above polymer generally met the requirements of retort processing, detailed investigations were conducted and the material was evaluated, pending the development of a suitable laminated material for the purpose (Table 3)

This resulted in developing a processing and packaging system for several Indian foods (Table 4) with a shelf life ranging from 4-6 months.

Table 3. Characteristics of PP Film TQ Grade

	PP	Required
Sterilization Temp.	115-145°C	115-145°C
Seal strength	2.2 kgs/10mm	2-35kgs/10mm
Heat seal range	160-175°C	150-250°C
Burst strength	10 kgs/cm^2	7.5 kgs/cm^2
Thickness tolerance	±20%	±2%

Table 4

(1) Sooji Halwa	(8) Beans in sauce
(2) Alu cholay	(9) Kofta curry
(3) Kabuli channa curry	(10) Kichidi
(4) Vegetable pulav	(11) Upma
(5) Mutton pulav	(12) Kachodi
(6) Mutton curry	(13) Sambar rice
(7) Kheer	(14) Ground mutton in gravy

The entire process essentially consists of cooking the food to a predetermined degree and processing in a special retort. The scheme is given below:

Preparation of the food
↓
Weighing and transfering into pouches
↓
Sealing of pouches
↓
Enclosure in specially designed Al. moulds
↓
Heat processing
↓
Cooling
↓
Drying at 60-70°C
↓
Packing in protective packaging

It has been found that though the film does not soften at the processing temperature it does undergo a slight change in physical properties. Due to this and also to protect the pack from any external mechanical damage, a protective packaging system which completely immobilises the pouch was designed. Various available materials (Table 5) were subsequently evaluated.

Table 5. Outer protective packaging

(1) Rectangular cartons
(2) Polystyrene trays
(3) 500 micron PUDC Trays
(4) Die cut kraft board
(5) Kraft board (micro-fluted)

After extensive evaluation and keeping in view the economic viability, the kraft board (microfluted) was found to be most suitable and adequate.

Several transportation user trials have indicated the complete reliability of the pouch. The foods remain microbiologically safe and organoleptically acceptable within the stipulated shelf life. A pilot plant scheme for the production of several varieties of ready-to-eat foods in polypropylene pouch have been formulated.

Based on the above technology developed by DFRL, limited quantities of retort processed foods have been supplied to the following specialised missions and expeditions and found to be extremely popular.

Expedition	Foods supplied
(1) Antarctica Expedition I, II, III and IV	*(i)* Sooji halwa *(ii)* Alu cholay *(iii)* Channa curry
(2) Everest expedition	*(i)* Sooji halwa *(ii)* Mutton curry *(iii)* Alu cholay *(iv)* Beans in sauce
(3) Landing party ration	*(i)* Sooji halwa *(ii)* Beans in sauce *(iii)* Vegetable pulav *(iv)* Mutton curry *(v)* Mutton pulav

Thus it may be concluded that a highly sophisticated food technology has been rendered into a practical reality by basing it entirely on indigeneous know-how, equipment and packaging materials. The production scheme is intended to provide a boost to the development of indigeneous technology for large scale production.

Thermal Processing of Low Acid Food Products in Rigid and Flexible Packaging Materials

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ABSTRACT

The basis, technological development, problems and future needs in the thermal processing of low—acid food products in rigid metal and flexible packaging materials are discussed.

Preservation of food by thermal processing was developed under stress of Napoleonic wars towards the early part of the ninteenth century by Nicholas Appert. The process consisted of adding sufficient water to cover the food in glass bottles, placing the corks loosely on the top, heating in a water bath to obtain a temperature of 190-212 °F at the centre of the container and sealing air-tight by driving in the corks. Appert ascribed the preserving action of the method developed by him as due to the exclusion of air. Gay Lussac, who studied Appert's process concluded that spoilage in foods was essentially a process of oxidation which could be prevented by exclusion of air from the container. Louis Pasteur, around 1860 discovered that microorganisms were the real cause of spoilage, and by heating, they are destroyed; thus enabling the food to be preserved in containers. He introduced the word 'pasteurization'.

Peter Durand obtained the first British patent in 1810 on canning of foods in tin containers. The development of the autoclave around 1874 by Shriver, and the commercial introduction of sanitary cans around 1900 paved the way for high speed economical can production, hermatic packaging and heat processing of foods. The pioneering work of Prescott and Underwood and others, during the latter part of the ninteenth century and the early part of the present one on the microbiology of heat processed foods, marked the introduction of science to the preservation of foods by thermal processing. Bigelow and Esty around 1920 showed the time-temperature relationship in the inactivation of spore suspensions of known concentration. The use of thermocouple by Bitting and Bitting around 1917 enabled measurement of temperature during heating and cooling of foods. The pioneering work of Bigelow, Ball and others around 1920, led to the development of graphical and mathematical procedures for establishing thermal process requirement to produce 'commercially sterile' and adequately pasteurized food products. These procedures integrate the heat resistance of the food spoilage microorganisms with the time-temperature data during heating and cooling of canned foods.

The period between 1910 and 1940 witnessed the discovery of many vitamins, their importance in human nutrition and during the latter part studies carried out to determine the heat stability of vitamins in foods indicated the higher sensitivity of thiamine to heat as compared to other vitamins. Consequently, thermal process given should be the minimum necessary to destroy the microorganisms responsible for spoilage of the canned foods without endangering the health of the consumers. These findings emphasized the need for greater precision in the determination and calculation of process time, and increasing the rate of heat penetration into canned foods which heat by conduction.

Temperature distribution studies in conduction heating canned foods demonstrated that a greater portion of the contents in the can was being severely overprocessed to achieve sterility of a small volume at the geometric centre. To change the mode of heat transfer from conduction to convection, and to eliminate the overprocessing resulting from non-uniform temperature distribution in conduction heating foods, agitation methods were established. Among them 'axial' and 'end-over-end' methods have become popular.

Another landmark in the history of development of canning is of high temperature short time (HTST)

processing. This was equivalent to sterilization at lower temperatures for longer times. The HTST processing was less destructive to the nutritional and organoleptic qualities. The use of high temperatures required for maximum quality retention either in still or agitating retorts resulted in increased stress which the sanitary cans were unable to withstand. To obviate this difficulty, aseptic canning was developed by Martin of Dole Corporation. In this method, the food is heated and cooled in specially designed heat exchangers, and then transferred aseptically into presterilized containers. However, certain deteriorative enzymes were found to be relatively more resistant to HTST processes than to low-temperature long-time processes. In such cases, enzyme inactivation would dictate the minimum process requirement. Hence, studies on kinetics of enzyme destruction became mandatory to render the HTST process successful.

The development of continuous agitating cookers and containers that permit the use of temperatures as high as 270 °F (132.22 °C) have enabled a high rate of production. Equipment have been designed to measure the temperature of the product in containers in agitating cookers, and the thermal resistance of the bacterial spores at temperatures as high as 270 °F (132.22 °C). Mathematical procedures have been developed to calculate the equivalent processes for still and agitation retorts. Improvements in instrumentation, automation and continuous processing have been rapid. Equipment have been developed for rapid heating and cooling of various foods, high-speed sterilization of metal containers and aseptic canning.

The history of development of thermal processing is well covered in the literature[1-8].

In India, the first canning factory is reported to have been started in late twenties of this century in Bombay. The huge requirement of the canned products and the difficulties encountered in their imports during the First World War, paved the way for development of this industry in India. The problems faced in importing canned foods during the Second World War proved a boon and a few large scale industries sprang up in places like Bombay, Calcutta and Delhi. However, planned development of the processing industry in India commenced with the enactment of Fruit Products Order in 1955.

Thermal Process Requirement

Foods contain microorganisms which might cause decomposition, food-borne infection or food-poisoning, unless completely inactivated. Under conditions of commercial sterility, organisms which are likely to cause spoilage or endanger the health or the consumers must be destroyed, while complete sterility with respect to other microorganisms is not required. A canned food must be subjected to heat for sufficient time at a particular temperature to produce a condition of commercial sterility. This heat treatment is called as thermal processing.

The process requirement was determined by the "cut-and-try method" for about hundred years following Appert's discovery. But this method was inadequate to cover the wide range of spoilage microorganisms and variable heating and cooling rates[9]. With advances made in the field of bacteriology and their wide application to the spoilage problems of the canning industry, process evaluation was put on a scientific basis. The steps involved in evolving a thermal process are: *(i)* determination of the heat resistance of spoilage organism with which the food might be contaminated under normal conditions; *(ii)* determination of the rate of heat penetration into the canned food under investigation; *(iii)* calculation of the theoretical process by coordination of the thermal death time data and the heat penetration data; and *(iv)* checking the calculated process by the inoculated pack studies[10].

Thermal resistance of microorganisms

pH is the most important determinative factor in the heat resistance of microorganisms, and thermal processing of foods. From the point of view of thermal processing, foods have been divided into three groups on the basis of pH: high-acid (pH less than 4.0), acid (pH between 4.0 and 4.5) and low-acid pH above 4.5). The dividing line between acid and low-acid foods has been carefully chosen to be slightly lower than the minimum pH of 4.6 at which *Clostridium botulinum* can grow[11].

Most organisms, if actively growing (vegetative state), are readily killed by exposure to temperatures near the boiling point of water. The resting stage or the spores are more resistant than the vegetative cells.

Microorganisms causing spoilage of foods

The principal microorganisms causing spoilage of low-acid canned foods are *B. stearothermophilus* from aerobic spore-formers, and *Cl. botulinum*, *Cl. thermosaccharolyticum* and *Cl. butyricum* from anaerobic spore-formers.

The spoilage of high-acid foods is caused by non-sporulating bacteria (*lactobacilli* and *leuconostoc)*, yeasts and moulds. Among the moulds, *Byssochlamys fulva* is more important. Though the heat resistance of yeasts and moulds is low, they should be completely inactivated as otherwise, they may grow, raise the pH to 4.5 or above, and create conditions favourable to the growth of *Cl. botulinum*.

Species and strains to be studied

In acid and high-acid foods, the problem is one of destroying a population of nonpathogenic microorganisms and/or enzymes which might cause spoilage, but in low-acid foods, *Cl. botulinum* can grow and cause food poisoning which can prove fatal to the consumers. Hence, the process schedule for all such foods should ensure complete destruction of maximum number of spores of this bacteria to give a safe product.

Factors affecting thermal resistance of microorganisms

Inherent resistance, environmental factors prevailing during the growth and formation of cells or spores, and *(iii)* environmental factors at the time of heating cells or spores, influence the resistance of microorganisms to heat. Inherent resistance varies with species and with the strains of the same species. Concentration, temperature of growth medium in which spores are formed exert widely varying influence on the heat resistance. The environment of microbial cells at the time of heating, viz., acids, pH, salt, sugars and other carbohydrates, fats, proteins etc., has a marked influence. Generally, heat resistance decreases with a decrease in the pH of the suspending medium. Sugar and other carbohydrates, fats and proteins protect the microorganisms from heat. Sodium chloride, up to about 4% increases, while higher concentrations tend to decrease the resistance[12].

Since various factors prevailing during growth and subculturing, and specially during heating, considerably affect the thermal resistance, the heat resistance studies are carried out by suspending the microorganisms in the food for which the thermal process is required to be evolved. Procedures to be followed in thermal death time (TDT) studies have been given by NCA[13].

Determination of thermal resistance of microorganisms

The methods used to determine the thermal resistance of microorganisms are thermal death time (TDT) tube method, TDT can method, tank method, flask method, thermoresistometer method, unsealed tube method, capillary tube method, TDT pouch method, and TDT cylinder method. Stumbo[12] has discussed advantages and disadvantages of these methods. TDT tube, TDT can and capillary tube methods are commonly used.

Death of microorganisms or their spores when subjected to moist heat above the maximum growth temperature, generally, follows the first order kinetics. Stumbo[12] has discussed the theories proposed to explain the logarithmic order of bacterial death.

The Arrhenius equation, the TDT, and the thermal resistant curves describe the temperature dependence of microbial inactivation. In Arrhenius equation, terms 'k' (reaction rate constant) and 'E_a' (activation energy); in TDT curves, 'F' (i. e. number of minutes required to destroy a given number of organisms at a given temperature) and 'z' (number of °F required for the TDT curve to traverse one log cycle); and in the thermal resistance curves, 'D' (decimal reduction time, i. e., time in minutes required at a constant temperature to destroy 90% of the organisms present) and 'z' are used to express the thermal resistance. 'Q' value; (temperature coefficient), often used, describes the response of the biological systems to temperature changes[11]. Jonsson *et al*[14]. in a comparative study found them to be identical.

Thermal destruction data can be plotted in the form of TDT curve which was first suggested by Bigelow[13] and expressed in the form of F value, or as thermal resistance curve and expressed as D value[12], first suggested by Katzin[15]. F value varies with the initial number of cells, while the D value is independent of it. Hence, the D value can be used to compare the heat resistance of the microorganisms but not the F value.

Sterilization safety

Clostridium and *Bacillus* species can grow and sporulate in low acid foods. To observe sterilisation safety, the D value—the time in minutes required to kill 90% of the microorganisms—is of great importance. For example, an autoclave can hold 1000 cans and each can contains 1000 bacteria, and the sterilization reduces the microorganisms in each can from 1000 to 0.001 (6 D units). If 1000 cans is taken as one unit, the original population of bacteria in the autoclave is 10^6. The 6-D reduction leads,

therefore, to one surviving spore in 1000 cans or one blown can.

To protect the consumers from the toxic hazard of *Cl. botulinum,* and considering the thermal death time (F_o=2.45) and D value (D_{250}^{18}=0.204), the 12 D concept has been accepted. This means that an F value of 12×0.204=2.45 min is necessary for reduction of the number of bacteria of *Cl. botulinum* of at least 10^{-12}. This heat treatment of the 12 D concept with about 3 min at 250 °F to kill *Cl. botulinum* or a similar combination of time and temperature is called botulinum cook. All low acid foods should receive a minimum botulinum cook equivalent to F_o of 3.0 from the public health view point[16]. Apart from *Cl. botulinum,* the mesophilic heat resistant spores of *Cl. sporogenes* (PA 3679) is the cause of rot which can lead to blowing, and the D_{250} value ranges from 0.1-1.5. The 5D of *Cl. sporogenes* is generally considered as equivalent to 12 D of *Cl. botulinum.* Hence, thermal processing of low acid foods should ensure sterility with respect to heat resistant organisms which demands processing more severe than botulinum cook.

The spores of thermophilic bacteria, however, germinate only at higher temperatures (113-132 °F) and their heat resistance is high (*Cl. thermosaccharolyticum,* D_{250}=3.0 to 4.0; *B. stearothermophilus,* D_{250}=4.0 to 5.0). A sterilization process that is guaranteed to kill thermophilic spore forming microorganisms, in other words absolute sterility, would lead to over-cooked products without any nutritive value if applied to canned food. Hence, it is better to control the existence and number of microorganisms before sterilization by using raw materials and ingredients having a low bacterial count and by adopting good manufacturing practices.

The thermal resistance of various microorganisms which cause spoilage of canned products has been listed by P flug and Odlang[16], Linger and Beverloo[17], Lund[11], Stumbo[12] and Ranganna[18]. Mulley *et al.*[19] suggested thiamine destruction as chemical index for evaluation of thermal pocess.

Heat Penetration into Canned Foods

Temperature changes during heating and cooling must be measured accurately to determine adequate process for canned foods. Although thermometers could be used to follow heating characteristics of foods, the most satisfactory method involves the use of copper-constant thermocouples[18]. Thermocouple assemblies are of two types—continuous[20] and non-projecting plug-in type[21]. The former has the disadvantage that it cannot be put into cans before sealing because of the projecting thermocouple wires. Hence, the latter is commonly used.[18] The thermocouple wires should be of about 40 gauge as the larger diameter wires conduct heat into the product, and thus give higher temperature. The error introduced with the wires of this small diameter due to conduction of heat along the wires and due to cooling of the media around it is negligible for cans of diameter above 307. Radiotelemetry has been used for recording temperature in continuous, agitating retorts[22].

Determination of cold point

When a can is being processed, the zone of slowest heating is called the cold point of a container[18]. The temperature is measured at the cold point. The position of the cold point depends upon the can geometry. In cylindrical cans, it is on the central axis at the geometric centre for conduction heating foods; at about one-tenth of the height of the can from the bottom for convection heating foods; and in between these two extremes for products which exhibit broken heating curves[23]. However, the cold point should be experimentally determined by placing the thermocouples at different points in initial tests. Alstrand and Ecklund[24], Ball and Olson[25], and Ranganna[18] have described the procedure to be followed in carrying out the heat penetration tests.

Plotting of heat penetration data

Thompson used thermal diffusivity to study the effect of nature of food on the rate of change of temperature, but Ball used the slopes of heating (f_h) and the cooling (f_c) curves[25].

The heat penetration data is plotted on a rectangular graph paper for evaluation of thermal process by graphical method, and on a semi-log paper for formula methods. NCA[13], Stumbo[12] and Ranganna[18] have treated this topic in detail.

Calculation of Process Time

Different methods available for the calculation of the process time may be classified into two groups: *(i)* those based on the survival at the cold point of the can, and *(ii)* those based on probability of survival in the whole container[18]. Procedures for the determination of process schedule by the classi-

cal methods have been well documented by NCA[13], Stumbo[12] and Ranganna[18]. Hayakawa[26] has made a critical review of the mathematical methods of thermal process calculations. The classical methods reported for process calculation by the NCA[13] are the improved graphical method of Bigelow *et al.,* the formula method of Ball, and the nomogram method of Olson and Stevens. In the methods developed by Stumbo[12] an iso-j region that encloses somewhat one-tenth or less of the total can volume was of greater concern and the survival outside this iso-j region is negligible. However, very significant amounts of the heat-vulnerable quality factors may be retained in the outer most regions of container. The formula of Stumbo for the determination of sterility has been modified to calculate the retention of the quality factors.

In the count reduction system proposed by Yawger[27], the cans inoculated with known concentrations of microorganisms are taken out from the processing line at different intervals and subcultured to determine the number of the surviving bacteria. The data so obtained are used to calculate the lethality of the process. This method is specially suitable for evolving thermal process by flame sterilization where it is difficult to get a reliable heat-penetration data.

Based on the formula method of Ball, computers have been used to calculate the process time[28–30]. Bimbert *et al.*[31] connected the can thermocouple directly to an anologue computer which gave directly the sterilizing value of the process. Teixeira *et al.*[32] developed a computer programme on the basis of the formula developed by Stumbo to calculate the F value and nutrient retention in conduction heating foods.

Most of the research work has been devoted to the study of conduction-heating foods in which the heat penetration is slow. The temperature of the product at different points in the containers is different, and it is difficult to predict mathematically the temperature pattern of the canned food. Comparatively little work has been done in the case of convection-heating products, as the temperature and hence, the lethality is assumed to be uniform throughout the can[25]. Procedures based on calculation of the lethality at single point are ideal for convection heating products as the temperature remains essentially uniform at all the points in the can due to the movement of the convection currents.

Inoculated Pack Studies

Accuracy of the calculated process time is checked by inoculated pack studies for microorganisms, and by experimental pack studies for enzymes. In the inoculated pack studies, first introduced by Russel[33], the cans are inoculated with a high concentration of test microorganisms, processed, incubated and checked for survival. Inoculated cans are processed for different periods in such a way that after incubation almost 100% spoilage occurs at the lowest level of sterilization and none in the highest. For low-acid foods, processing schedule is evolved with respect to destruction of *Cl. botulinum.* As it is a pathogen, the nonpathogenic bacteria *Cl. sporogenes* (PA 3679) and the flat-sour bacteria *B. stearothermophilus* (FS 1518) are used as the test microorganisms. In acid foods, *Cl. pasteurianum* and *B. coagulans,* and in high acid foods, lactobacilli, yeasts and moulds are used as the test microorganisms. Ball and Olson[25] and NCA[13] have described the procedure to be followed for inoculated pack studies.

The experimental pack studies are conducted in the same way as inoculated pack studies except that no microorganism is inoculated into the cans. The residual enzyme activity in the canned product is checked immediately after processing and during storage.

A process should be so designed that the extent of spoilage is not more than 1% and desirably below 0.01%[12, 13].

Flexible Package

Flexible packages (pouches) for shelf stable food products are new compared to glass and metal containers. The pouches made of thermoplastic and foil laminate has proved technically and commercially feasible. American work during 1950s led to the development of state of art but most of the commercial applications found place in Japan and Europe. Long[34] listed the requirements for retort pouch films. Material generally used in a 3-ply laminate is based on a sandwich of aluminium foil (9-25μm thick) with an outer ply generally made from polyester (12 μm thick) which protects the aluminium from scuffing and gives strength to the pack, and an inner ply made of either high density polyethylene or a polypropylene copolymer (50 to 80 μm thick) depending upon the seal characteristics and ability to withstand contact with fat, oil and other components of food. The adhesive

conventionally used for bonding the plies together is a polyester-isocyanate. The pouches should be able to withstand sterilization temperature of 240-300 °F; oxygen permeability of 0 cc/m^2/24 h/atm.; moisture vapour transmission rate of 0 g/m^2/24h; seal strength of 2-3.5 kg/10 mm; bond strength of 150-500 g/10 mm; heat seal range of 320-500 °F; inner ply thickness tolerance of ± 2 micron, 10% value±7.0 g/m^2; bursting strength of 7.5 kg/15 mm seal, 17.2×10^4 pascal for 30 sec and residual solvent (taint) 30 mg/m^2 (0.5 ppm as toluol).

The pouch made from polypropylene based material is more suitable for higher processing temperatures of 240°-250°F than the modified high density polyethylenes. In Japan, using pouches made of 12 μm polyester/9 μm aluminium foil/15 μm oriented Nylon/6/50 μm polypropylene, the products are processed by HTST method at 275 °F for 2.7 to 9 min (Lampi[34]). According to Lampi[35], the nominal thickness of pouch ranges from 1.58 cm for the 114 g size to 3.33 cm for the 909 g size and is of flat rectangular shape with four fin seals about 1 cm wide, and with notches provided for easy tear opening.

Due to flexible nature of the pouch, handling exerts pressure on the seals which may result in leakage. To prevent leakages and even if it occurs, to prevent contamination from organism of public health significance, the pouches are packed in rectangular flat cartons which provide a good surface for decorative and display purposes.

After filling the product into the pouches, vacuum is created either by squeezing the product into the headspace region whilst sealing or by using vacuum sealing machine. Pouches are sealed by means of heated pressure plates or jaws for which purpose, the inner ply should be of thermoplastic material like polypropylene or high density polyethylene. In any case, the dwell time for the sealing operation is about 1 second.

Sterilization is carried out in overpressure system like water-cook system used for glass jars or air-steam retorts. In the former, sterilization of the pouches is carried out under water with an overpressure of air to prevent distension of pouches. The operating pressure ranges from 1.4 to 2.5 bar depending upon the type of pack and temperature of processing. In the latter method, by maintaining a uniform mixture of air and steam through forced circulation as otherwise stratification occurs due to variation in density, pouches can be processed. The latter type is mostly used in Japan. Microwave technique has also been applied but laminated pouches containing aluminium foil are not suitable for this purpose. Shelf-life of foods packed in foil-free pouches is enhanced by packing the processed pouches in a foil containing aseptic over pack.

In the course of processing of pouches, the pack geometry should not change. The pouches when kept vertically tend to bulge at the bottom resulting in an increase in the cross-sectional area at the lease and change the heat-penetration characteristics. The pack geometry is maintained by the use of racks (which restrains the thickness within predetermined limits) when the pouches are processed in the vertical position, or by processing in the horizontal position. Stork, hydromatic and FMC manufacture the retorts suitable for the purpose. An over-pressure of air is maintained during cooling of pouches.

Temperature measurement and process evaluation

Changing from rigid containers to flexible containers using the known F_o value is relatively simple if the heating characteristics of the packages under actual commercial processing conditions are known. Thickness of the geometry of the pouch is restricted by fixed geometry racking. The thermocouple tip is normaly held at the anticipated pack centre or, in the case of products containing pieces of appreciable size, at the centre of a solid piece. Heat penetration into the flexible pouches is measured by inserting flexible copper-constantan (30 gauge) lead wires through a hole in the wall of the pouch and placing the tip at the desired position with the help of a plastic spacer, or a modification of the same. The hole is sealed with a simple epoxy resin cement seal or rubber gaskets.

Thermocouples do not lend conveniently to the continuous system of processing, and hence, either the count reduction technique at different intervals of processing or temperature telemetry system may be made use of. Chemically treated papers which can be calibrated in 10°F increments, and sealed into glass tubes have been suggested for measuring initial temperatures as non-metallic sensors must be used.

Heating characteristics viz., f_h, j and F_o used in evolving the process schedule of rigid containers

have been found adequate for use with flexible pouches also.

The process time required in flexible pouches is considerably lower as compared to canned food. To achieve at 250 °F an F_o of 5.2 for 5 oz. Chicken a' la King, process time required in a flexible pouch was 10 min as against 35 min in the can.

Readers may refer to the review by Lampi[35], dissertation of Woon[36] and the book on Canned Foods—Thermal Processing and Microbiology by Hersom and Hulland for more detailed information on the subject of processing of low acid foods in flexible pouches.

Concluding Remarks

The cumulative knowledge gained over years in the science and technology of evolving thermal process schedule for low-acid foods have rendered the canned products absolutely safe. Reports of food poisoning due to consumption of canned foods are almost nil or very rare.

Flexible pouch for low acid foods is a reality. Technology was developed in USA where it is yet to make a beginning in a big way but Japan produces 400 million packs per year. The inherent simplicity of the pouch, makes it a strong candidate for packing ethnically acceptable formulations in developing countries. To ease concern over under-sterilization, lowering the pH through acidification and control of water activity may be considered. Designing of simple filling and sealing methods for preformed pouches and process retorts; and establishing rudimentary procedures for assessment of pouch strength are needed.

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Changes in Fruit Juice Packaged in Flexible and Rigid Containers

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ABSTRACT

Storage studies were carried out under three conditions of (i) 40°C/35% R. H. (ii) 27°C/65% R. H. and (iii) refrigerated condition to evaluate the protective qualities of polyester/aluminium foil/polyethylene and metallized polyester/polyethylene laminated pouches as compared to tin—plate containers by storing orange juice. Chemical, biological and organoleptic changes in the juice as influenced by the storage conditions and packaging materials were investigated. Based on changes in the ascorbic acid, acidity, browning index and also microbiological and organoleptic analyses, it was found that foil laminate pouches afforded shelf—life of 45, 65 and more than 90 days whereas metallized polyester/polythylene pouches provided corresponding shelf—life of 34, 65 and more than 90 days under the three conditions. There were minimal changes in the product packed in tinplate containers with only slight feathering at the high temperature storage.

Introduction

Fruit juices and squashes are generally packed and sold in rigid containers, mostly glass bottles and metal cans. Recent innovations in this field include easy to open ends for cans and light-weight glass bottles. Though these containers have served the industry well for a long time, they are heavy, expensive and difficult to transport and do not offer the consumers many advantages. Efforts are being made in recent years to replace the rigid containers with high barrier flexible packaging materials.

Flexible pouches are light in weight, easy to process, fill and seal, offer good chemical resistance. They are available in various sizes and shapes and are easy to handle and open. Further, they are free from tin and lead migration problems and by far, the greatest determinant in using pouches is their economical cost and convenience. In this study, the protective properties of polyester/aluminium foil/ polyethyline pouches and the newer one made of metallized polyester/polyethylene pouches were compared with tin-plate containers to package orange juice.

Materials and Methods

Orange juice was prepared from fresh coorg mandarin variety. 170 ml of the juice was filled into the pouches at a temperature of 85-90°C and immediately sealed, and in the case of cans, they were seamed. The two types of stand-up pouches used were: *(i)* 12 micron metallized polyester/100 micron polyethylene (MP) and *(ii)* 12 micron plain polyester/12 micron aluminium foil/100 micron polyethylene. The metal can used was No. 1 tall plain can with a differential tin-coating of 1 and 0.5 lb with an outside lacquer.

The filled containers were stored at three conditions, as under *(i)* 40±2°C with 35-40% RH, *(ii)* 27±1°C with 65±2% RH, and *(iii)* refrigerated condition, 3 to 5°C. The samples were withdrawn at intervals and analyses were carried out for chemical, biological and organoleptic qualities.

Initially, the flexible packaging materials were tested for their water-vapour and oxygen transmission rates, tensile and heat-seal strengths. The juice was intially, and after it is packed in containers analysed by standard methods for *(i)* Total soluble solids (Brix), *(ii)* Titratable acidity, *(iii)* Ascorbic Acid content, *(iv)* Organoleptic evaluation by numerical scoring. Microbiologically testing was carried out for total bacterial, yeast & mould counts and fermentation tests.

Results and discussions

1. *Packages:* The physico chemical properties of the two flexible packaging materials are given in the table 1. Metallized polyester/polyethylene material had WVTR of 0.69 g/m.^{2}d and oxygen transmission rate of 4 Ml/m.^{2}d. atm. The foil based laminate

Table 1. Physico-chemical properties of pouch materials

Property		Metallized PE/PE	PE/Foil/PE
1. Tensile Strength, >J< KN/m, >J<	MD	2.96	3.50
	TD	3.09	3.48
2. Elongation, %	MD	>32	33
	TD	>32	35
3. Heat-Seal Strength %		45	32
4. Water-vapour Transmission g/m^2. d @ 38°C/90% RH		0.6	Nil
5. Oxygen Transmission, Ml/M^2. day. atm. @27°C.		4	Nil

had permeabilities of less than the measurable quantities by the standard methods adopted.

2. *Total Soluble Solids:* This did not show much change during the storage period in any of the three storage conditions in all the three types of containers (18-23° brix)

3. *Acidity as anhydrous citric acid:* Acidity of the orange juice also did not show much change in the case of cans and pouches during the storage periods (1.057-0.77).

4. *Ascorbic acid content:* The results are indicated in the table 2.

Cans: From the results, it is indicated that there was nearly 30% less of ascorbic acid present in the orange juice during the storage period of 91 days (3 months) at low temperature. The losses were 32% at normal temperature at the end of 91 days of storage and at the end of 50 days at high temperature.

PF pouches: In the case of foil pouches, therc was 43% loss during the storage period of 91 days at low temperature. The losses were 90% and 52% at normal temperature during 91 days and 50 days at high temperature respectively.

MP Pouches: From the results, it is clear that there was 36% loss in ascorbic acid present during the storage period of 91 days at refrigerated condition. The losses were 94% and 93% at room temperature-during 91 days and 50 days of storage at high temperature storage respectively.

From the figures, we can conclude that as to be expected cans fared well at all the storage temperatures, being the best barrier package system. At the high and normal temperature conditions foil laminate pouch offered better protection to ascorbic acid as compared to metallized polyester. This could be attributed to the higher oxygen permeability of the metallized web. At the low temperature condition, although cans provided very good protection, there was not much difference between the two flexible packaging materials tested.

5. *Organoleptic evaluation:* Orange juice stored in cans at low temperature was taken as control and the sensory qualities of colour, odour and taste were evaluated. The total quality of the juice is considered as overall acceptability. The changes in the overall acceptability score with storage period are shown in table 3. The results show that, as to be expected cans indicated a consistant higher score in all the three conditions of storage. At the high temperature condition, MP pouches were rated to be acceptable only upto 35 days whereas FP pouches at 48 days. In the normal storage condition, the shelf life for the juice was 65 days for the two types of pouches. At the refrigerated condition, the product remained acceptable even at the end of 90 days storage. There was

Table 2. Ascorbic acid content of fruit juice stored in packages Ascorbic acid (mg) content indicated during storage period (days)

Packaging material	40°C			27°C						Low temperature					
	14	30	49	14	30	49	64	79	91	14	30	49	64	79	91
Tinplate can	23.0	22.7	22.2	26.0	25.0	26.0	25.0	23.0	22.0	27.2	26.0	26.0	26.0	24.0	23.0
Polyester, foil, poly	25.0	18.5	15.8	22.1	21.6	15.8	7.1	4.3	3.5	—	24.3	—	24.0	19.4	18.6
Metallised polyester/PE	19.6	3.1	2.5	20.6	4.1	3.9	3.5	2.2	2.0	—	24.7	—	24.7	22.6	21.0

Initial value 32.68 mg%

Table 3. Average organoleptic score of fruit juice stored in packages

Packaging material	40°C			27°C						Low temperature					
	14	30	49	14	30	49	64	79	91	14	30	49	64	79	91
Tinplate can	9.0	9.0	9.0	9.3	9.1	9.1	9.0	9.0	9.0	10	10	10	10	10	10
Polyester/foil/ poly	0.6	6.2	4.8	9.0	8.2	6.1	5.1	4.8	4.7	—	80	—	7.2	7.2	7.0
Metallised polyester/poly	9.0	5.4	3.4	9.0	6.9	5.7	5.0	4.3	4.0	—	7.8	—	7.5	6.2	6.0

Maximum score—10.
Acceptable level—5.

not much difference between the foil based and metallized polyester pouches, but cans fared superior.

6. *Microbiological evaluation: Microbiological* tests for total plate count, yeast & mould counts and fermentation test in orange serum broth of samples of orange juice packed in metal cans and in flexible pouches at different storage temperatures for variable periods has shown that there was no spoilage in the product in all the three packaging systems.

Due to the lower weight of flexible pouches and lesser processing time and lower freight charges, they may prove economical compared to tin-plate containers for short-term storage periods. Introduction of cold storage points and improved transport facilities are sure to help in the introduction of flexible pouches for packing fruit juices.

Packaging and Storage Studies of Fruit and Vegetable Products in High Density Polyethylene Containers

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ABSTRACT

As economic alternative to conventional metal and glass containers, HDPE containers have been considered in recent years for packaging fruit products. They offer certain advantages like ligh weight, nonfragility, noncorrosiveness, easy dispensability etc. However, it is desirable to evaluate these containers for safety of use and suitability for packaging of fruit products. Preliminary studies have been initiated to evaluate the suitability of HDPE containers for typical fruit and vegetable products like tomato ketchup, orange squash, and lime and mango pickles in oil. The study has revealed the suitability of HDPE containers for packing tomato ketchup and pickles (mango and lime). On the other hand, HDPE containers were found to be unsuitable for packing orange squash as the loss of flavour and pick up of foreign odour were considerable during storage.

Rigid food grade plastic containers like high density polyetheylene (HDPE) and polyvenylchloride (PVC) have been considered in many countries for packaging of various food products. These offer certain advantages like light weight, non fragility, non-corrosiveness, easy dispensability, etc. and as such, can be suitable alternatives to conventional glass and metal containers. In India, their use is limited as they are not yet cleared by the Ministry of Health for want of adequate research data on their safe use and suitability for packaging fruit products. Only HDPE (GF 5260) containers are being used for packaging vanaspathi and low density polyethylene pouches for packaging of pasteurized milk. Different aspects of plastic containers for food application has been reviewed earlier[1] and also suitability of HDPE and PVC containers for some fruit products have been evaluated[2,3]. The present study was undertaken to evaluate the suitability of HDPE containers manufactured in the the country for packaging of typical finished fruit products like orange squash, tomato ketchup and pickles in oil. The quality changes in these products during storage and the storage life of the same are presented in this paper.

Materials and Methods:

Containers used for tomato ketchup were *(a)* Narrow mouthed HDPE bottles (GF 5260), 150mm height with 55mm base diameter, 20mm neck diameter and 1.8mm thickness with volume capacity 0.5 l.

(b) Glass bottle: standard size ketchup bottle as control and *(c)* HDPE pouches of 100mm × 100mm size to hold 50 g of the product as single shot consumer unit pack (HDPE 300 gauge)

Containers used for orange squash were

(a) HDPE bottles (GF 5260) of height 275mm, base dia. 69mm, neck dia, 22mm and 1.7mm and wall thickness with a capacity of 700 ml.

(b) Standard size squash glass bottles and

(c) 300 gauge HDPE pouches of 100 × 100mm to hold 50 ml of the products.

(d) 300 MXXT cellophane to wrap HDPE bottles.

Containers used for pickles in oil were

(a) Wide mouthed HDPE containers of height 138mm, base dia. 69mm and neck dia 50mm with wall thickness of 0.7mm and capacity 500 ml.

(b) Wide mouthed 16 oz standard size glass bottles.

(c) 300 gauge HDPE pouches of 100 × 100mm to hold 50 mm of product.

Raw materials:

(i) Tomato ketchup: Fresh fruits purchased from local market and used in all the experiments. Tomato ketchup was prepared as per the recipe given by Giridhari Lal et al[4].

(ii) Orange squash: Juice was extracted from fresh ripened oranges and squash was prepared as per recipe given by Giridhari Lal[5].

(iii) Freshly prepared mango and lime pickles in oil was used.

Extraction tests on HDPE containers: In order to test whether the containers used is food grade or not, xylene and hexane extraction studies were carried out as per code of federal regulations (USA)[6] and Indian Standards[7]. From the HDPE containers cut into two halves, plastic powder was scraped from the inside of the containers using stainless steel knife and powder so obtained was subjected to extraction tests.

Packaging and storage conditions: Containers thoroughly washed in hot water (60-70°C) and dried were used to pack the products i. e. hot ketchup (70°C) orange squash and pickles at room temperature. After filling they were closed with inserts, heat sealed and subsequently screw capped. HDPE pouches were heat sealed after filling with the products.

Filled containers were stored under the following conditions.

(i) Accelerated conditions of 38°C, 90% RH.
(ii) —do— 40°C,30-40% RH.
(iii) Indian standard condition of 27°C, 65% RH
(iv) Refrigerated condition (4°C)

Representative samples were withdrawn at regular intervals of time and the quality of the products was assessed by physicochemical, microbiological and organoletpic parameters.

Chemical Analysis: pH was determined using digital single electrode pH meter. Total solubles were determined in an Abbe's Refractometer. Total titrable acidity was determined by titrating against standard sodium hydroxide solution and expressed either as per cent acetic acid (W/W) or as anhydrous citric acid. Preservatives benzoic acid and sulphur-dioxide were determined by standard AOAC methods[9]. Extent of browning in stored ketchup was estimated by measuring the OD at 420nm as per method of Luh[10]. Total carotenoid pigments in stored orange squash was determined as per the method of Roy[11]. Ascorbic acid in squash was estimated as described by the Association of Vitamin Chemists[12]. Sunset yellow FCF dye content was determined by standard method[13]. Reducing sugars and total sugars were estimated by Lane and Eynon's method[14]. Free fatty acids (FFA) and peroxide value (PV) were determined by standard methods[15],[16]. Microbial count as per method of Tanner[17], Organoleptic evaluation was conducted by a panel of judges on a 9 point Hedonic scale[18].

Results and Discussion

Extraction tests on containers: The extraction in hexane at 50°C expressed as % by weight for different HDPE containers and film used ranged between 0.4 to 1.0% as against the maximum permissible extractive limits of 5.5% for food grade polyethylene. Similarly the extractives in xylene at 25°C expressed as per cent by weight ranged between 2.0 and 3.5% for containers and was 5.4% for HDPE film as against the maximum permissible limit of 11.5%. The extractive values indicate the safety of use of the containers as the extraction limits are far lower than permissible limits for food grade containers.

Tomato ketchup storage studies: Storage behaviour of Tomato ketchup in different containers under different conditions of storage is presented Table. 1. There was no appreciable change in pH, total soluble solids (TSS) preservative and titratable acidity in stored products under all conditions of storage, in different containers. However, the extent of browning in the stored product in terms of O. D. value was considerable in plastic containers compared to one packed in glass bottle. The O.D. values increased steadily with time and temperature and the product becoming darker and darker. The results suggests that a O.D. value of 0.35 to 0.4 is critical with respect to color changes and acceptability of the product. Above a value of 0.4 the product develops unattractive blackish brown color. Similar observations of pronounced browning and oxidation in tomato puree in plastic containers have been reported[2], [3]. The higher rate of browning observed in plastic containers can be attributed to both oxidation due to considerable permeability of oxygen through the plastic containers and also due to non-enzymatic browning reactions which is favoured at higher temperature.

Table 1. Tomato Ketchup

Sl. No.	Storage Conditions	Storage period in days	Type of container	Parameters								
				pH	TSS (%)	Acidity (%) as acetic acid	Benzoic acid ppm	O.D.	Total Bacterial count (million/cc)	Yeast count no. of cells/1/60 cmm	Mould %+ve fields	Organoleptic evaluation
1	2	3	4	5	6	7	8	9	10	11	12	13
Initial values				3.65	28.50	1.60	680	0.15	22	10	2	9
1.	92% RH & 38°C (Accelerated)	30	PCH	3.62	28.00	1.59	660	0.27	22	10	2	6
		45	PCH	3.64	27.50	1.58	620	0.39	22	11	4	6
			PB	3.60	28.40	1.56	640	0.26	22	11	2	6
2.	30—40% RH and 40°C	30	PCH	3.66	28.40	1.60	650	0.28	22	11	2	6
		45	PCH	3.66	28.20	1.55	620	0.36	22	12	2	5.5
		„	PB	3.64	27.90	1.58	650	0.29	22	10	2	5.5
		„	G1B	3.68	28.20	1.59	660	0.37	23	11	2	6.5
		90	PB	3.64	28.40	1.56	620	0.39	23	11	2	4.0
		„	G1B	3.68	28.20	1.59	650	0.37	23	11	2	4.0
3.	65% RH and 27°C	30	PCH	3.65	28.00	1.60	654	0.28	24	10	2	7.0
		45	PCH	3.65	27.80	1.50	640	0.38	24	11	2	6.5
		„	PB	3.66	27.80	1.60	652	0.32	22	11	2	7.5
		„	G1B	3.65	28.50	1.60	665	0.22	22	10	2	8.0
		90	PCH	3.70	27.50	1.50	620	0.38	24	12	2	7.7
		„	PB	3.70	27.80	1.60	645	0.32	22	11	2	7.0
		„	G1B	3.69	28.00	1.60	660	0.22	24	10	2	7.5
		180	PBM	3.72	27.60	1.59	620	0.59	24	10	2	5.0
		„	G1B	3.70	28.00	1.59	655	0.39	24	12	2	6.5
4.	Refrigerated condition (4°C)	45	PCH	3.68	27.50	1.58	665	0.28	23	10	—	7.5
		„	PB	3.65	28.40	1.56	665	0.29	22	11	—	7.5
		„	GLB	3.64	28.40	1.60	660	0.28	22	11	—	8.5
		90	PCH	3.70	27.40	1.56	650	0.35	23	10	—	7.0
		„	PB	3.69	28.00	1.54	660	0.39	23	11	—	7.0
		„	GLB	3.68	28.30	1.59	658	0.37	23	11	—	8.5
		180	PCH	3.72	27.20	1.55	635	0.40	24	11	—	6.5
		„	PB	3.72	27.80	1.52	654	0.40	24	12	—	6.5
		„	G1B	3.69	28.10	1.58	650	0.38	24	12	—	8.0
		240	PCH	3.77	38.40	1.55	610	0.45	24	12	—	5.5
		„	PB	3.75	27.00	1.50	650	0.44	24	12	—	5.5
		„	GLB	3.70	28.00	1.57	659	0.40	24	12	—	8.0

PCH = HDPE pouches; PB = Plastic bottle; GLB = Glass bottle.

Complimentary to color changes, there was gradual decrease in organoleptic quality of the product under all conditions of storage in different containers. In general the acceptability scoring was higher at particular condition of storage for glass bottle stored product, followed by HDPE container and pouches Eventhough organoleptic evaluation of the product indicated that with a score of 5.5 and above the product is acceptable, a cut-off value of 6.0 was choosen as critical with reference to the acceptability of the product.

From the trend in changes of O.D. values and also organoleptic scoring it can be inferred that tomato ketchup packed and stored in HDPE pouches, bottles and glass bottles will have a storage life of about 30, 90 and 90 days respectively under accelerated condition of storage. Similarly at 65% RH and 27°C the product will have a safe storage life of about 60, 120 and 180 days in HDPE pouches, HDPE bottle and glass bottles respectively. In refrigerated condition the product was quite acceptable without much noticable change in organoleptic quality for a period of 180 days in HDPE pouch and bottle and for 240 days in glass bottle.

F.P.O. has prescribed limits for microbial count in tomato ketchup for overall quality evaluation. It was observed that the limit of microbial count was well within the permissible limits in all packages studied.

From the above study, it can be inferred that the tomato ketchup in HDPE containers will have comparable storage life, Similar to glass container eventhough the overall quality of the product in HDPE container is slightly inferior compared to glass at the end of respective terminal shelf life periods under all conditions of storage.

Orange squash storage studies: Practically no change in pH, TSS and titratable acidity in the product packed in different packages and stored under different conditions of storage was observed (Table 2). However under all conditions of storage there was pronounced loss of sulphur dioxide (SO_2) in orange squash stored in HDPE bottle and pouch. Sulphur dioxide content at accelerated condition changed from 345 ppm to 145 ppm at the end of 180 days storage in HDPE bottle without any wrap and it was 95 ppm in HDPE pouch within 45 days. However, the loss of sulphur dioxide can be considerably minimized by overwrapping the HDPE containers with "saran coated cellulose film" (MXXT cellophane); The sulphur dioxide content in this wrapped container being 195 and 300 ppm at 38°C and 27°C respectively. Considerable loss of sulphur dioxide through HDPE film and container is in accordance with permeability data on the plastic films reported by Davis, et al[19]. and the trend reported by earlier workers[2, 3]. Thus, the loss of sulphur dioxide can be attributed to high permeability characteristics of HDPE containers and as such suitably wrapping with MXXT cellophane which has low permeability to sulphur dioxide will help in minimizing the loss during storage. Carotenoid content in the stored squash was considerably reduced under all conditions of storage with maximum change under accelerated condition and minimum in refrigerated (cold) condition. In the HDPE containers without wrap having higher oxygen permeability, the break-down of pigments due to oxidation is found to be higher compared to HDPE bottles with MXXT wrap and glass bottles.

Changes in total sugars in stored orange squash were not significant in all containers under different conditions of storage. However, there was slight increase in reducing sugars in all packages which can be attributed to partial hydrolysis of sugars during storage. Initial vitamin C content of 18 mg per cent in the product also got reduced to 6.5, 9.5 and 12.1 mg per cent in HDPE bottle without wrap, with wrap and glass bottle respectively at the end of 220 days storage at 65% RH and 27°C. The losses were still higher at higher temperature. The greater loss of Vitamin C in HDPE bottle is also due to oxygen permeability characteristics of the plastics.

Sunset yellow FCF dye content also considerably reduced in all packages and the fading of color was more under accelerated condition. However, it is surprising to note that the maximum color changes occurred in glass bottles compared to HDPE bottles. Thus, it appears that translucent HDPE bottles are better than transperant glass with respect to color retention.

Change in organoleptic quality under all conditions of storage was more pronounced in HDPE containers due to considerable loss of flavour. However, the organoleptic quality of the orange squash packed in HDPE bottles and wrapped with MXXT cellophane was comparable to glass bottle stored product. Even in glass bottles the product at the end of 180 days storage under accelerated conditions had burnt flavour and was just acceptable.

Table 2. Orange Squash

	Storage Conditions	Storage period in days	Type of containers	Parameters											
				pH	TSS (%)	Acidity % as Citric Acid	Total SO_2ppm	Free SO_2ppm	Bound SO_2ppm	Sunset yellow FCF dye mg/kg	Vitamin Cmg/100g	Total sugars % as invert sugar	Free red. sugar (%)	Total Carotenoid pigments μg/100g	Organoleptic evaluation
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
		Initial	values	2.50	47.00	1.15	345	140	205	125	18.00	45.00	28.50	85.00	9.0
1.	92% RH & 38°C (Accelerated)	45	PCH	2.50	47.50	1.14	95	65	30	30	—	—	—	—	2.5
		,,	PBNW	2.50	47.50	1.14	235	129	106	106	—	—	—	—	7.00
		,,	PBW	2.50	47.50	1.13	280	97	183	183	—	—	—	—	7.50
		,,	GLB	2.50	47.00	1.15	321	109	212	212	—	—	—	—	8.50
		90	PCH	—	—	—	—	—	—	—	—	—	—	—	—
		,,	PBNW	2.48	47.50	1.12	190	85	105	—	—	—	—	—	6.50
		,,	PBW	2.47	47.50	1.12	240	60	180	—	—	—	—	—	7.00
		,,	GLB	2.48	47.00	1.14	304	190	114	—	—	—	—	—	8.00
		180	PBNW	2.45	47.50	1.11	145	46	99	27.0	6.90	44.6	37.50	—	5.00
		,,	PBW	3.46	47.60	1.11	210	90	120	31.0	9.00	44.5	39.00	—	5.50
		,,	GLB	2.46	47.20	1.12	300	187	113	23.0	10.10	45.5	39.60	—	7.00
2.	30.40% RH & 40°C (Accelerated)	45	PCH	2.50	47.00	1.12	90	56	34	—	—	—	—	—	2.50
		,,	PBNW	2.50	47.00	1.14	220	125	95	—	—	—	—	—	7.00
		,,	PBW	2.50	47.00	1.13	276	100	176	—	—	—	—	—	7.50
		,,	GLB	2.50	47.00	1.15	315	105	210	—	—	—	—	—	8.50
		90	PBNW	2.49	47.50	1.16	174	75	99	—	—	—	—	—	6.50
		,,	PBW	2.50	47.50	1.13	230	70	160	—	—	—	—	—	7.00
		,,	GLB	2.48	47.00	1.15	300	200	100	8.00	—	—	—	—	8.00
		180	PBNW	2.43	47.20	1.14	150	60	90	25.00	6.20	44.70	36.90	—	5.00
		,,	PBW	2.46	47.60	1.00	175	80	95	29.00	8.90	44.90	38.20	—	5.50
			GLB	2.48	47.00	1.10	290	190	100	21.00	9.40	44.60	32.90	—	7.00

Table Contd.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3.	65% RH & 27°C	45	PCH	2.50	47.20	1.15	105	58	47	—	—	—	—	—	—
		,,	PBNW	2.50	47.00	1.15	289	175	114	—	—	—	—	—	—
		,,	PBW	2.50	47.00	1.15	319	140	179	—	—	—	—	—	—
		,,	GLB	2.50	47.00	1.15	330	95	245	—	—	—	—	—	—
		90	PCH	2.46	47.50	1.18	95	57	38	16.60	9.80	44.50	35.50	10.50	3.0
		,,	PBNW	2.48	47.20	1.16	227	90	137	—	—	—	—	—	8.0
		,,	PBW	2.47	47.00	1.14	310	140	170	—	—	—	—	—	8.0
		,,	GLB	2.48	47.00	1.14	330	120	210	—	—	—	—	—	8.5
		180	PBNW	2.46	47.30	1.16	190	140	50	—	—	—	—	—	5.0
		,,	PBW	2.45	47.20	1.17	300	150	150	—	—	—	—	—	6.5
		,,	GLB	2.46	47.50	1.14	325	130	195	—	—	—	—	—	8.50
		220	PBNW	2.45	47.50	1.15	192	160	32	6.50	44.80	—	22.00	—	6.0
		,,	PBW	2.44	47.30	1.15	500	180	120	9.50	44.00	—	39.00	—	6.5
		,,	GLB	2.45	47.20	1.15	320	120	100	12.10	38.00	—	39.00	—	7.00
4.	Refrigerated condition 4°C	90	PCH	2.46	42.50	1.11	190	95	105	83.00	2.90	—	—	—	7.5
		,,	PBNW	2.46	47.00	1.14	280	130	150	—	—	—	—	—	8.0
		,,	PBW	2.45	47.00	1.16	300	140	160	—	—	—	—	—	8.5
		,,	GLB	2.49	47.00	1.14	340	180	160	—	—	—	—	—	8.5
		180	PCH	2.46	47.30	1.12	180	90	90	67.00	2.9	44.50	38.60	—	7.5
		,,	PBNW	2.45	47.00	1.17	275	220	155	—	—	—	—	—	8.0
		,,	PBNW	2.48	47.50	1.14	290	150	140	—	—	—	—	—	8.5
		,,	GLB	2.46	47.50	1.16	335	180	175	—	—	—	—	—	8.5
		220	PBNW	2.44	48.00	1.17	260	100	160	49.00	10.60	44.50	39.50	69.00	7.0
		,,	PBW	2.46	47.60	1.13	280	100	180	66.00	11.46	44.50	42.50	78.00	8.0
		,,	GLB	2.45	46.80	1.17	330	170	160	96	13.70	44.50	39.60	79.00	8.0

PCH: HDPE Pouch; PBNW: Plastic bottle with no wrap; PBW: Plastic bottle withwrap; GLB: Glass bottle.

Thus, results indicate the limitation of HDPE containers for packaging of orange squash as concommitant loss of flavour, sulphur dioxide and pick up of foreign plastic odour, restricts the storage-life. Greater permeability characteristics of HDPE containers is the limiting factor of its use as alternate packaging media to conventional glass containers. The use of HDPE pouch as a single shot unit pack is limited and at best the product is acceptable for 30 days at 27°C. Similarly at 27°C, the product can be expected to have a storage life of 120 days in HDPE bottle overwrapped with MXXT cellophane. However, at 4°C as losses in sulphur dioxide and flavour is minimal, the product retains all the characteristics of the original squash in both HDPE with wrap and glass containers and can be expected to have storage life of 220 days.

Mango and Lime pickles in oil--storage studies: Practically no change in pH titratable acidity in the products was observed under all conditions of storage in different types of containers (Table 3). However, under all conditions FFA and PV in both products increased steadily in all containers. The highest being in HDPE pouch and lowest in glass bottle. Further, this increase was considerable under accelerated temperature and both products appeared darker than the normal red color. Also in general mango pickles became soft in all containers including glass bottles.

It was observed that the products with organoleptic scoring of below 6.5 is critical with respect to acceptability of the product. As such for shelf-life calculation, the product with an organoleptic score

Table 3. Mango & lime pickle in oil

Sl. No.	Storage Condition	Storage period in days	Type of container	pH	Acidity % as acetic acid	FFA (%) as Oleic acid	Peroxide value milli moles PV/ kg oil	Organoleptic evaluation
1	2	3	4	5	6	7	8	9
Initial values			MP	2.50	2.50	0.19	—	9.0
			LP	2.48	2.00	0.20	—	9.0
1. 92% RH & 38°C Accelerated		60 MP	PCH	2.49	2.52	0.58	16.22	4.0
			PLB	2.48	2.51	0.49	1.29	6.50
			GLB	2.49	2.50	0.36	0.95	7.50
		60 LP	PCH	2.44	2.05	0.85	18.30	4.0
			PLB	2.40	2.09	0.43	2.03	6.5
			GLB	2.40	2.04	0.42	1.00	7.5
		120 LP	PLB	2.46	2.53	0.91	3.56	6.0
		120 MP	GB	2.48	2.51	0.52	1.94	7.0
		120 LP	PLB	2.42	2.05	0.59	2.43	6.5
			GLB	2.39	2.08	0.64	2.26	7.5
		180 MP	PLB	2.44	2.55	1.05	5.20	5.0
			GLB	2.46	2.52	0.92	2.60	6.5
		180 LP	PLB	2.40	2.08	1.10	6.40	5.50
			GLB	2.36	2.09	0.80	4.65	6.5
2. 30-40% RH & 40°C		60 MP	PCH	2.44	2.45	1.49	18.00	4.0
			PLB	2.48	2.52	0.84	1.90	6.5
			GLB	2.48	2.52	0.48	0.90	7.0
		60 LP	PCH	2.40	2.08	0.89	11.90	4.0
			PLB	2.45	2.04	0.90	1.00	6.5
			GLB	2.45	2.04	1.30	1.00	7.5
		120 MP	PLB	2.47	2.54	0.91	2.10	6.0
			GLB	2.47	2.56	0.68	4.94	7.0
		120 LP	PLB	2.44	2.08	1.30	2.20	6.5
			GLB	2.44	2.10	1.30	2.10	7.5
		180 MP	PLB	2.40	2.56	0.98	8.20	5.0
			GLB	2.47	2.58	0.79	12.60	6.5
		180 LP	PLB	2.40	2.10	1.49	6.40	5.5
			GLB	2.42	2.12	1.39	20.60	6.00

Table Contd.

1	2	3	4	5	6	7	8	9
3.	65% RH & 27°C	60 MP	PCH	2.50	2.51	0.35	2.00	4.0
			PLB	2.50	2.51	5.00	—	7.5
			GLB	2.50	2.50	0.82	—	8.0
		60 LP	PCH	2.50	2.05	0.48	0.05	4.0
			PLB	2.38	2.00	0.78	—	7.5
			GLB	2.45	2.00	0.54	—	8.0
		120 MP	PLB	2.48	2.52	0.50	3.9	7.0
			GLB	2.47	2.50	0.82	—	8.0
		120 LP	PLB	2.36	2.12	0.90	3.90	7.0
			GLB	2.42	2.05	0.64	—	8.0
		180 MP	PLB	2.46	2.52	0.57	4.60	6.5
			GLB	2.46	2.51	0.89	2.20	7.0
		180 LP3	PLB	2.35	2.22	0.99	4.00	6.5
			GLB	2.38	2.15	1.10	8.80	7.5
		240 MP	PLB	2.48	2.56	0.64	5.20	6.0
			GLB	2.40	2.62	1.10	3.60	7.5
		240 LP	PLB	2.44	2.43	1.20	4.10	6.5
			GLB	2.40	2.20	1.40	3.50	7.5
4.	Refrigerated condition 4°C	60 MP	PCH	2.49	2.51	0.50	1.20	8.0
			PB	2.48	2.51	0.19	0.10	8.5
			GLB	2.49	2.50	0.18	0.14	8.5
		60 LP	PCH	2.46	2.00	0.74	0.65	8.0
			PB	2.46	2.00	0.32	1.40	8.5
			GLB	2.46	2.00	0.30	0.90	8.5
		120 MP3	PCH	2.48	2.52	0.80	1.80	8.5
			PB	2.46	2.52	0.42	3.00	7.0
			GLB	2.48	2.51	0.24	0.95	8.0
		120 LP	PCH	2.45	2.02	0.90	0.90	7.5
			PB	2.45	2.01	0.50	1.95	7.0
			GLB	2.45	2.00	0.39	2.86	8.0
		180 MP	PCH	2.48	2.54	0.24	5.28	6.0
			PB	2.45	2.52	0.51	5.00	6.5
			GLB	2.47	2.52	0.32	5.20	7.5
		180 LP	PCH	2.49	2.04	1.64	2.20	6.0
			PB	2.44	2.01	1.09	5.20	6.5
			GLB	2.45	2.05	0.47	6.00	7.5

PCH=HDPE pouches; PB=Plastic bottle; GLB=Glass bottle.

of 6.5 and above can be considered as acceptable and below this value it can be considered not acceptable.

From the trend in the changes of FFA, PV and also based on quality, it can be said that both lime and mango pickles packed in HDPE pouches, HDPE bottles and glass and glass bottles will have a storage life of about 20, 60 and 120 days respectively under accelerated conditions. Similarly at 65% RH and 27°C, the corresponding storage-life will be about 40, 150 and more than 180 days respectively. Thus, it can be inferred from the above study that pickles packed in HDPE containers will have comparable storage life similar to glass bottles eventhough the overall quality of the products in HDPE is slightly inferior compared to glass. Further, results suggest the possible use of HDPE containers for packaging of pickles as alternative to conventional glass bottles.

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Sterilisation of Milk in Flexible Pouches

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ABSTRACT

Sterilization of milk in flexible pouches was carried out by auto claving at 115°C for 18 and 20 min and at 120°C for 4 and 5 min. There was appreciable loss of nutrients and colour change in milk sterilized at 115°C for longer duration of 18-20 min. However, least effect on the quality of milk was observed when the in-pouch sterilization was done at 120°C for 4 min, providing complete sterility during the storage period of 30 days. Also, changes in Polypropylene film were minimum at this temperature/time treatment. In conclusion, heat treatment of milk in flexible pouches at 120°C for 4 min is recommended.

Introduction

Milk is a perishable commodity and has low shelf-life. The seasonal variation in production of milk often poses difficulties in the availability of milk throughout the year for the lack of an appropriate processing and storage technique. In tropical countries like India refrigeration takes a major share in processing, storage and transporation costs, thereby increasing the cost of the product to a considerable extent. One of the solutions to these problems is to sterilise the milk so that it can be *stored under normal ambient conditions.* The ultra high temperature sterilisation requires costly equipments and controls, and in-bottle sterilisation often causes breakage of bottles during processing and transport. Moreover, the bottles are expensive and non-disposable. Flexible packages have a definite advantage over bottles as they are cheaper, occupy less space, easy to dispose and involve no breakage during processing or transport. Materials like polypropylene, polyester, nylon and vinyl films possess important properties such as seal integrity, toughness, puncture resistance, grease resistance and can withstand high temperatures. Thus there is a good scope for the use of flexible packages in the sterilisation of milk. Keeping these points in view, **a research project** was undertaken to study the feasibility of sterilising milk in flexible pouches. The effect of sterilisation on product quality, deteriorative changes in sterilised milk during storage and the variation in the mechanical properties of the flexible package material due to heat treatments were studied.

Materials and Methods

The experimental technique comprised a series of operations described below:

Preparation of pouches:

Polypropylene film (250 gauge) was used for making the flexible pouches. Superweld multi-purpose infra-red heat pulse controlled polyethylene welding machine was used for sealing purpose. The pouches were prepared with effective dimensions of 12 cm×10 cm and having a milk filling capacity of 150 ml. The width of sealing was 3 mm.

Homogenisation of milk:

Fresh milk preheated to 60°C on a LPG gas stove was homogenised at a pressure of 100 kg/cm^2 in order to avoid the formation of cream-line during storage.

Milk filling and sealing:

Each pouch was filled with 125 ml of homogenised milk leaving sufficient space for expansion during heating. After filling, the pouches were sealed from the top.

Sterilisation of milk:

Sterilising equipment: A twelve-litre pressure cooker of 'Prestige' make was used as a pressure chamber for sterilising in-pouch milk. A pressure gauge was fitted to the top of the lid. Provision

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was made for two thermocouple wires to measure the temperature of the product and the chamber. A safety valve was fitted to the lid separately. An arrangement was also made for supplying compressed air to the pressure chamber. A removable crate with three shelves was placed in the pressure chamber to hold the milk filled pouches.

Sterilisation procedure:

Water was filled in the pressure chamber to a height of 5 cm. Six pouches filled with homogenised milk (cow or buffalo) were loaded on the crate and placed in the pressure chamber.

The connections for fixing the thermocouple wire with one of the pouches were made and then the chamber was tightly closed with lid. The valve connecting the pressure chamber and air compressor was closed. The pressure chamber was then heated on gas stove. Air inside the chamber was first allowed to be driven out and then the steam outlet was closed so that the chamber pressure started building up. Both the product and the steam temperature were recorded at one minute interval. After attaining the required product temperature the intensity of gas flame was adjusted to maintain this temperature throughout the desired holding period. The following **four** time-temperature combinations were tried in this study: *(i)* heating at 120°C for 4 and 5 min and *(ii)* heating at 115°C for 18 and 20 min.

After holding period the stove was put off. The valve connecting the air compressor and the pressure chamber was opened slightly. Air was sent inside the pressure chamber and was allowed to come out, along with the steam after condensing it partially, through the pressure release valve. During air cooling same pressure was maintained in the chamber to prevent the bursting of the pouches. The product temperature was brought down to 70°C by air cooling. The lid was then opened and pouches were taken out and kept in the atmospheric air for further cooling. The cooled pouches were stored at room temperature.

Qualitative analysis of the sterilised milk:

The sterilised milk samples were analysed for standard plate count, ascorbic acid content, browning reaction, pH and sterility to determine the quality changes due to the heat treatment. These tests were performed on 0, 10, 20 and 30th days of storage under normal ambient conditions

Determination of the mechanical properties of pouch material:

The shape, strength and integrity of pouch depend on the mechanical properties of the pouch material. The properties, viz. tensile strength, compression strength and bursting strength were determined for the polypropylene film before and after the heat treatment. The tensile and compression strength were determined using 'Instron' TM-M model universal testing machine and the bursting strength was measured by using an apparatus especially designed for the purpose.

Results and Discussion

(a) Performance of the pressure chamber:

The pressure cooker performed well as milk steriliser. There was absolutely no leakage of steam at the joints. Once the process started, it took 2 min to remove the air from the pressure chamber. The temperature of milk reached 115°C and 120°C in 14 and 16 min respectively. There was no difference in the nature of product temperature rise with chamber temperature for both cow and buffalo milk. It was noticed that the chamber temperature during holding period was 1°C higher than the product temperature.

(b) Qualitative assessment of milk immediately after sterilisation treatment:

The results of the qualitative assessment of both raw and sterilised milk are presented in Table 1. The effects of the heat treatment on various parameters are discussed below:

Standard plate count: The standard plate counts of the milk samples were found to be within the recommended safe limit of 100 per ml, indicating that all the heat treatments resulted in proper sterilisation of milk.

Ascorbic acid content: In case of cow milk the loss of ascorbic acid was observed to be in the range of 35 to 43 per cent. For buffalo milk this loss was slightly less ranging from 28 to 37 per cent. The loss of ascorbic acid was higher in the milk samples sterilized at 115°C for 18 or 20 min. compared to the samples sterilized at 120°C for 4 or 5 min. This indicated that the loss of ascorbic acid depended more on heating time than the temperature of the treatment.

Browning effect: Browning effect was more pronounced at 115°C than at 120°C irrespective of

Table 1. Qualitative analysis of milk before and after sterilization

Sl. No.	Type of milk	Sterlization temp. °C and time, min	Standard plate count no. per ml of milk		pH		Ascorbic acid mg/ml			Browning micro-moles HMF/litre of milk	
			before sterili-zation	after sterili-zation	before sterili-zation	after sterili-zation	before sterili-zation	after sterili-zation	percent decrease	before sterili-zation	after sterli-zation
1.	Cow	120, 4	3,50,000	12	6.86	6.82	21.20	13.80	34.90	0.53	4.90
2.	Cow	120, 5	3,50,000	8	6.86	6.85	21.20	13.10	38.20	0.53	7.50
3.	Cow	115, 18	3,50,000	9	6.86	6.74	21.20	12.70	40.09	0.53	9.00
4.	Cow	115, 20	3,50,000	17	6.86	6.75	21.20	12.20	42.45	0.53	11.40
5.	Buffalo	120, 4	6,70,000	22	6.84	6.78	19.40	13.90	28.35	0.74	3.30
6.	Buffalo	120, 5	6,70,000	13	6.84	6.83	19.40	13.30	31.44	0.74	4.60
7.	Buffalo	115, 18	6,70,000	18	6.84	6.75	19.40	12.90	33.50	0,74	5.60
8.	Buffalo	115, 20	6,70,000	7	6.84	6.74	19.40	12.30	36.59	0.74	6.90

Table 2. Mechanical properties of polypropylene film (250 gauge) before and after heat treatment

Sl. No.	Heat treatment temp. and time °C	min	Tensile strength kg/cm²	Percent elongation	Bursting strength kg/cm²	Compression stress kg/cm²
1.	Without heat		347.08	450	0.413	0.83
			345.19	464	0.435	0.83
2.	120,	4	304.25	428	0.419	0.83
	120,	4	302.99	410	0.405	0.83
3.	120,	5	301.10	462	0.403	0.83
	120,	5	302.36	446	0.402	0.83
4.	115,	18	328.18	436	0.422	0.83
	115,	18	325.66	424	0.413	0.83
5.	115,	20	318.11	446	0.419	0.83
	115,	20	322.51	432	0.434	0.83

the type of milk. This may be attributed to the longer heating time required at lower temperature. For the same heat treatment the cow milk exhibited greater browning than buffalo milk.

Sterility of milk: Aschaffenburg turbidity test conducted on all the treated milk samples resulted in clear filtrate and indicated negative result confirming that the samples were properly sterilised.

pH: A slight decrease in pH, ranging from 0.01 to 0.1 was observed after sterilisation with all the four heat treatments. There was less reduction in pH value during the heat treatment at 120°C for 4 or 5 min.

Effect of storage period on the quality of sterilised milk:

The in-pouch sterilised milk was stored safely under normal ambient conditions upto 30 days. There was no appreciable change in standard plate count and pH of samples during this period. Turbidity test after 30 days storage produced negative result. A loss of ascorbic acid ranging from 50 to 75 per cent was observed during this period. The browning of milk increased to approximately three times in 30 days as compared to the browning of fresh sterilized milk. The increase in browning was found to be more with longer period of heat treatment (115°C for 14 or 20 min) than that with shorter period (120°C for 4 or 5 min). The presence of oxygen in the pouch might have contributed to the ascorbic acid loss and browning of the milk.

Mechanical properties of the pouch material:

Mechanical properties of 250 gauge polypropylene film before and after the heat treatment are shown in Table 2. It may be noted that the tensile strength of this film, initially observed to be 345 kg/cm², was reduced to 318-320 kg/cm² and 301-304

kg/cm^2 respectively on heat processing at 115°C and 120°C. However, there was no appreciable change of the heat treatment on percent elongation of the film. Variation in the bursting strength of the polypropylene film after the heat treatment was negligible. The compression test conducted on pouches (filled with milk) before and after heat treatment indicated that the seal did not break even when a compressive load of 0.83 kg/cm^2 was applied over the pouch.

Conclusion

From the previous discussion it is obvious that all the samples confirmed effective in-pouch sterilisation of milk on heat processing at 115°C and 120°C. However, there was appreciable loss of nutrients and colour change in milk sterilised at 115°C. The least effect on the quality of milk was observed with the heat treatment at 120°C for 4 min. The samples treated under these conditions retained their sterility during the storage period. The polypropylene pouches remained in good condition after the treatment and during the storage period. The changes in mechanical properties of polypropylene film were minimum with the heat treatment at 120°C for 4 min. Hence the heat treatment at 120°C for 4 min. was recommended for in-pouch sterilisation of cow and buffalo milk.

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Packaging and Storage Studies of Partially Defatted Coconut Gratings

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ABSTRACT

A detailed study of the keeping quality of partially defatted coconut gratings was made at room temperature and at 42°C. It was found that partially defatted coconut gratings have better keeping quality than desiccated coconut. A shelf-life of 3 to 4 months can be easily obtained and under carbondioxide packing it can be prolonged to more than 5 months. Moisture proof packing was, however, found to be necessary, especially in humid climates.

India ranks third in the world in coconut production with an area of around one million hectares producing about 5700 nuts annually. This represents about 14.6% of the world area under this crop and 20.7% of the yield. Coconut has been a traditional item of food in India from very ancient times. About 57% per cent of the total production is even now directly used for edible purposes. Kernel of the mature nut is generally used as gratings in curries, subjies and breakfast foods. At present no modified or processed products from coconut except desiccated coconut are produced in India. As per the latest estimate, about 4000 tonnes of desiccated coconut are produced annually in India which are mainly used in the confectionery market. If a low priced product is made available, it is likely to find a good demand for household culinary purposes, especially in big cities. In view of this, the Regional Research Laboratory, Trivandrum has developed a new process for production of partially defatted coconut gratings[1] which can be used in many common food preparations like chutneys, curries, sweets etc. In this paper the results of storage studies of partially defatted coconut gratings in different packages and different conditions are reported.

Materials and Methods

A detailed study of the keeping quality of the partially defatted coconut gratings was made at room temperature (28-32°C) and at 42°C. For storage studies polyethylene bags, rigid PVC containers with screw cap and air tight tins were used. Carbon dioxide was filled after vacuumization. Moisture content of the products was measured by IR moisture meter. Sensory evaluation of the products for colour, taste, mouthfeel, absence of off-flavour and overall quality was carried out by a panel of 8 to 10 judges[2, 3]. The cut off sensory score from acceptability point of view was 6 out of 10.

Results and Discussion

The results of storage studies of coconut gratings at room temperature are shown in Table 1. After two months storage at room temperature the dried coconut gratings packed in air tight containers (PVC containers with screw cap) were in acceptable condition. Products packed under carbon dioxide were better and were comparable to reference samples (control sample stored at 0°C in air tight containers). Product packed in polyethylene bags (150 gauge) deteriorated rapidly in quality. For the dried coconut gratings the total sensory score was 5 compared to 8 and 10 for samples packed in air tight containers as such and with CO_2. The partially defatted coconut gratings were more stable in all the packages. The sensory scores were higher.

The moisture pick up in polythene package was high. In whole dried coconut gratings it increased from an initial value of 1.2% to 4.2% after two months and in the partially defatted coconut gratings the moisture increased from an initial value of 2.4 to 7.2.%. In PVC containers the moisture increased from an initial value of 1.2% to 2.2% and under CO_2 in the same package, it increased to 1.8% in the case of desiccated coconut. It was 5.0 and 4.4% in the case of partially defatted coconut gratings. Same trend followed on storage for 3 months. The partially

Table No. 1. Storage study of Coconut Gratings at room Temperature (28—32°C)

Sample	Characteristics	Storage period in months																			
		0			1			2			3			4			5			6		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	Moisture %	1.2	1.2	1.2	3.0	1.8	1.8	4.2	2.2	1.8	4.6	2.8	3.4	5.3	3.6	3.7	5.6	4.3	3.6	—	4.0	3.8
Desiccated Coconut	Acidity as mgm of KOH per gm of dry sample	1.2	1.2	1.2	2.7	1.8	1.7	3.3	2.4	2.3	3.8	2.3	2.7	6.7	4.2	3.3	8.9	3.8	3.2	—	4.3	4.1
	Sensory score	10.0	10.0	10.0	7.0	9.0	10.0	5.0	8.0	9.0	5.3	7.3	8.7	2.3	7.0	8.3	2.0	6.0	7.0	—	3.9	5.3
	Moisture %	2.4	2.4	2.4	6.4	3.8	3.8	7.2	5.0	4.4	8.2	5.4	4.6	8.4	6.0	6.0	8.6	5.5	6.2	—	6.0	6.0
Partially Defatted Coconut Gratings	Acidity as mgm of KOH per gm of dry sample	3.44	3.5	4.9	4.9	4.4	4.4	6.1	5.1	4.5	5.8	4.8	4.0	5.5	5.3	5.5	6.5	4.6	4.7	—	5.3	5.0
	Sensory score	10.0	10.0	10.0	7.0	8.0	10.0	7.5	9.8	10.0	5.7	8.7	8.7	5.9	7.7	8.7	4.3	8.3	8.5	—	2.6	4.5
	Moisture %	3.8	3.8	3.8	8.0	5.4	4.6	9.0	5.0	5.6	10.8	8.0	8.2	12.0	12.0	10.0	11.4	9.4	10.2	—	14.0	10.6
Solvent Extracted Coconut Gratings	Acidity as mgm of KOH per gm of dry sample	3.9	3.9	3.9	5.3	5.2	4.9	7.01	5.93	5.6	8.0	5.5	5.3	8.4	9.7	8.1	7.8	7.1	7.7	—	14.05	7.95
	Sensory score	10.0	10.0	10.0	9.0	9.3	9.8	7.3	9.0	9.8	5.7	8.0	8.0	2.0	5.5	8.7	3.3	6.8	8.5	—	2.6	4.5

A: Coconut gratings kept in polythene bags (150 gauge)

B: Coconut gratings kept in PVC containers

C: Coconut gratings kept in PVC containers packed under CO_2

Table 2. Storage study of Coconut Gratings at 42°C

Sample	Characteristic	Storage period in months													
		0		1		2		3		4		5		6	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B
Desiccated coconut gratings	Moisture % Acidity as mgm of KOH per gm of dry sample	1.1 1.81	1.4 1.81	1.4 1.93	1.4 1.70	2.2 1.84	1.6 2.40	2.0 2.37	1.6 2.05	1.6 2.97	1.6 2.87	1.6 3.53	1.2 2.47	1.4 2.92	1.4 3.04
	Sensory score	10.0	10.0	7.5	8.5	6.9	7.8	6.6	7.5	6.5	6.5	5.5	6.0	4.4	4.9
	Moisture	3.2	3.2	3.4	3.2	3.8	3.4	3.9	3.5	3.8	3.0	3.0	3.4	2.6	3.5
Partially defatted coconut gratings	Acidity as mgm of KOH per gm of dry sample	3.65	3.65	4.05	3.70	4.01	2.56	5.03	4.50	6.79	6.03	5.14	5.28	5.46	5.75
	Sensory score	10.0	10.0	8.5	8.9	7.8	8.0	7.5	7.8	7.0	7.5	6.4	6.5	5.1	5.3
	Moisture %	3.6	3.6	3.8	3.6	4.4	4.2	4.8	4.8	4.0	4.4	3.8	3.8	3.8	3.8
Solvent extracted coconut gratings	Acidity as mgm of KOH per gm of dry sample	4.20	4.20	4.42	4.41	6.14	5.29	5.08	6.47	5.68	3.87	5.30	4.73	5.42	5.07
	Sensory score	10.0	10.0	8.4	8.6	8.0	8.0	7.2	7.5	6.5	6.8	6.4	6.5	6.2	6.2

A: Coconut gratings in PVC containers

B: Coconut gratings in PVC containers packed under CO_2

defatted coconut gratings packed in PVC containers were acceptable. The products packed under CO_2 were better. At 42°C also (Table 2) Similar trend was seen but the moisture pick up was less.

Storage studies of partially defatted coconut gratings was continued both at room temperature and elevated temperature for 6 months. It was found that at the end of 5 months, samples of desiccated coconut stored at room temperature had become rancid and unpalatable. Samples stored under CO_2 packing showed only slight deterioration. Samples of partially defatted coconut gratings packed in PVC containers had not become rancid and were in acceptable condition.

Storage at elevated temperature showed browning particularly in desiccated coconut. Slight rancidity was also evident in desiccated coconut but the samples were crisp. CO_2 packing was found beneficial as the quality was good.

Based on these studies, further work was done on large scale and it was found that packing of partially defatted gratings can be done as bulk packing in tins. 20 litres capacity tins with wide mouth, like biscuit tins can be used. Drying to 2% moisture level was found to be beneficial for keeping quality. The partially defatted gratings have a shelf-life of 4 to 5 months if packed in moisture proof containers or packages. Packing under carbon dioxide was found to give a better quality product and very little deterioration was noticed even after six months.

Acknowledgement

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Studies on the Storage Life of Cod Fillets Using Controlled Atmosphere* Packaging

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ABSTRACT

Cod fillets were packed in a plastic moulded tray of size (18.5 cm × 13 cm × 5.5 cm) made of 400 μm PVC laminated with 100 μm polythene and sealed with 50 μm PVC film laminated with 100 μm polythene film. Sealing was done after flusing with 50% CO_2 and 50% oxygen in a vacuum sealing machine. Results of chemical, sensory and microbiological analysis of gas packed and air packed cod fillets stored at 0-2°C and 5-7°C revealed that the fillets can be kept for 19 days at 0-2°C in controlled atmosphere packaging compared to 11 days in air. At 5-7°C, the fillets could be kept in acceptable condition for a period of 11 days compared to air packed sample which kept well for a period of 5 days only. TVN values were lower at 0-2°C compared to those at 5-7°C. Microbial counts were also less at lower temperature compared to those at 5-7°C. It could be concluded from the above experiments that considerable extension of shelf life of cod fillets could be achieved at a temperature of 0-2°C under controlled atmosphere packaging.

Introduction

In recent years considerable interest has been envinced in many countries in research on storage of fresh meat, poultry and fish in modified or controlled atmosphere packaging. Fish is one of the most perishable of foods whose freshness is rapidly lost even when stored under chilled conditions. It is important that fish are consumed in as fresh a state as possible so that the sweet and desirable flavours which consumers prefer are still retained. The availability of whole and processed fresh fish to consumers away from landing and production areas is restricted due to the limited storage stability of such products. Even though bulk transportation of fresh fish in ice permits distribution in inland areas, bulk ice holding has several disadvantages:—

(1) Ice provides only a limited extension of life

(2) Freight charges of bulk ice transportation are high.

(3) Since the fish are not protected by overwrapping or other packaging, cross contamination and other forms of abuse cannot be avoided.

(4) Flooding of fish with water from melting ice during transportation results in unhygienic conditions, besides considerable leaching losses of soluble nutrients and flavouring compounds.

One method that could potentially obviate the deficiencies associated with bulk holding of fish in ice is controlled atmosphere packaging (CAP). This method which is currently being used to prolong the shelf life of pork, poultry and beef utilizes a carbon dioxide rich atmosphere which selectively inhibits the growth of bacteria (Coyne, 1932). Machinery has now been developed to such a stage where foods can be packaged in an atmosphere known to inhibit deteriorative changes. The atmosphere is carefully controlled at the time of packaging and hence the denomination "Controlled atmosphere packaging". CAP has been used successfully for meats, vegetables and dairy products and also proved effective for fish. Extensive trials with a variety of fish products and species at different temperatures have confirmed the effectiveness of carbon dioxide (CO_2) for extending their shelf life under chilled conditions. Although the fundamental functions

*This work was carried out as part of the training programme of the author under a NORAD fellowship in the University of Trondhim Norway

of carbon dioxide have not, as yet, been fully elucidated, it is apparent that when exposed to an atmosphere containing at least 20% CO_2, bacterial activity is inhibited, although autolytic changes proceed. Chemically and microbiologically 40% carbon dioxide is more effective in controlling the undesirable changes in rock fish fillets and silver salmon *(Oncorhynchus kisutch)* steaks (Duane Brown, *et al.,* 1980). About 60% carbon dioxide atmosphere has been found to be very advantageous in extending the shelf life of fresh red hake *(Urophycischuss)* packed in gas-impermeable bags (Fey and Regenstein, 1979). At Norway for the commercial packaging of cod fillets, a mixture of 50% carbon dioxide and 50% oxygen has been employed.

The objective of this present investigation is to determine the differences in the biochemical and microbiological changes that take place when cod fillets are stored under two different conditions, viz. 0-2°C and 5-7°C in controlled atmosphere and air.

Materials and Methods

Fillets of cod were packed in a factory in Norway in plastic moulded trays (65 Nos.) of 400 μ polyvinyl chloride laminated with 100 μ polythene and sealed with 50 μ polyvinyl chloride film laminated with 100 μ polythene film after flushing with 50% CO_2 and 50% oxygen in a vacuum sealing machine. Control samples without gas were packed i. e., in air for comparison. All these packets were transported to the laboratory in a refrigerated truck maintaining a temperature of 0°C packed in 3 ply corrugated fibre board cartons. The net weight of the fillets in each packet was around 300-350 g. Part of the samples were kept in a cabinet maintained at a temperature of 0-2°C (recommended temperature) and the rest in another cabinet maintained at 5-7°C. Four thermocouples were fixed in each cabinet to record the variations in the temperature every one hour during storage using a temperature recorder. Samples were drawn periodically using random sampling technique and the following analysis were carried out: (1) Moisture, (2) Total volatile nitrogen (TVN), (3) Total plate count (4) PH and (5) Sensory evaluation of the sample by visual observation on the quality.

Moisture

About 5 g of the fish sample was placed in a weighed aluminium foil, weighed again kept in a heating cabinet at 102-105°C and dried until constant weight.

PH

To about 5-10 g of the fish sample were added 5 times its weight of distilled water and homogenised using ultraturax homogeniser. PH of the slurry thus obtained was measured using a PH meter.

Total volatile nitrogen (TVN)

10-12 g fish muscle was weighed in a petridish and 40 ml of 10% trichloroacetic acid was added. The sample was homogenised for 2 minutes using ultraturax homogeniser and the mass filtered through ordinary filter paper into a standard flask. The extract was made up to volume and analysed for total volatile nitrogen using the method of Conway and Byrne (1933).

Total plate count

A sample of 10 g of fish muscle was asceptically cut from a fillet taken out from a packet into a sterile weighed petridish, weighed again and transferred to a sterile homogenisation tube containing 90 ml of 0.9% saline solution. It was homogenised for 2 minutes in an ultraturax homogeniser. Following the serial dilution technique, total bacterial count was determined using Tryptone glucose extract agar supplied by DIFCO laboratory, Michigan, USA. The plates were incubated at room temperature for a period of 3-4 days and the colonies counted.

Visual observation on the quality of the sample

The quality was evaluated by a panel consisting of 4 members. After taking the sample for microbiological examination, the fillets in the packets were subjected to visual observation as regards drip, colour change and spoiled smell. The samples were considered to be spoiled when all Judges reported spoiled smell with a sudden repulsion of the nose away from the packet.

Results and Discussion

Figure 1 indicates the flow sheet for the production of cod fillets using controlled atmosphere packaging. Temperature variations in the cabinet during the storage of cod fillets are presented in figure 2.

Table 1 indicates the chemical composition of cod muscle as reported by Taarland, *et al.,* 1958. It can be seen that cod is rich in protein and minerals.

Results of the chemical and microbiological analysis of gas and air packed fillets stored at a temperature of 0-2°C are presented in tables 2 and 3.

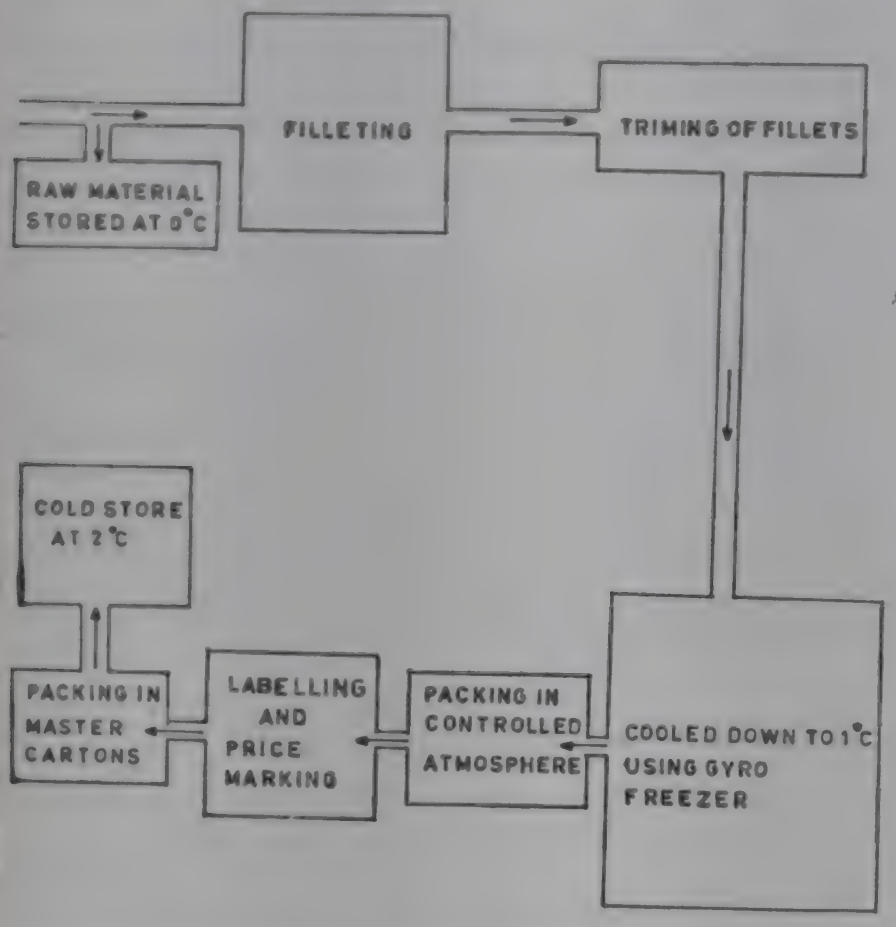
FILLETING
TRIMING OF FILLETS
RAW MATERIAL STORED AT 0°C
COLD STORE AT 2°C
PACKING IN MASTER CARTONS
LABELLING AND PRICE MARKING
PACKING IN CONTROLLED ATMOSPHERE
COOLED DOWN TO 1°C USING GYRO FREEZER

Figure 1. Flow sheet for the production of Cod Fillet/Saith Fillet using Controlled Atmosphere Gas Packaging

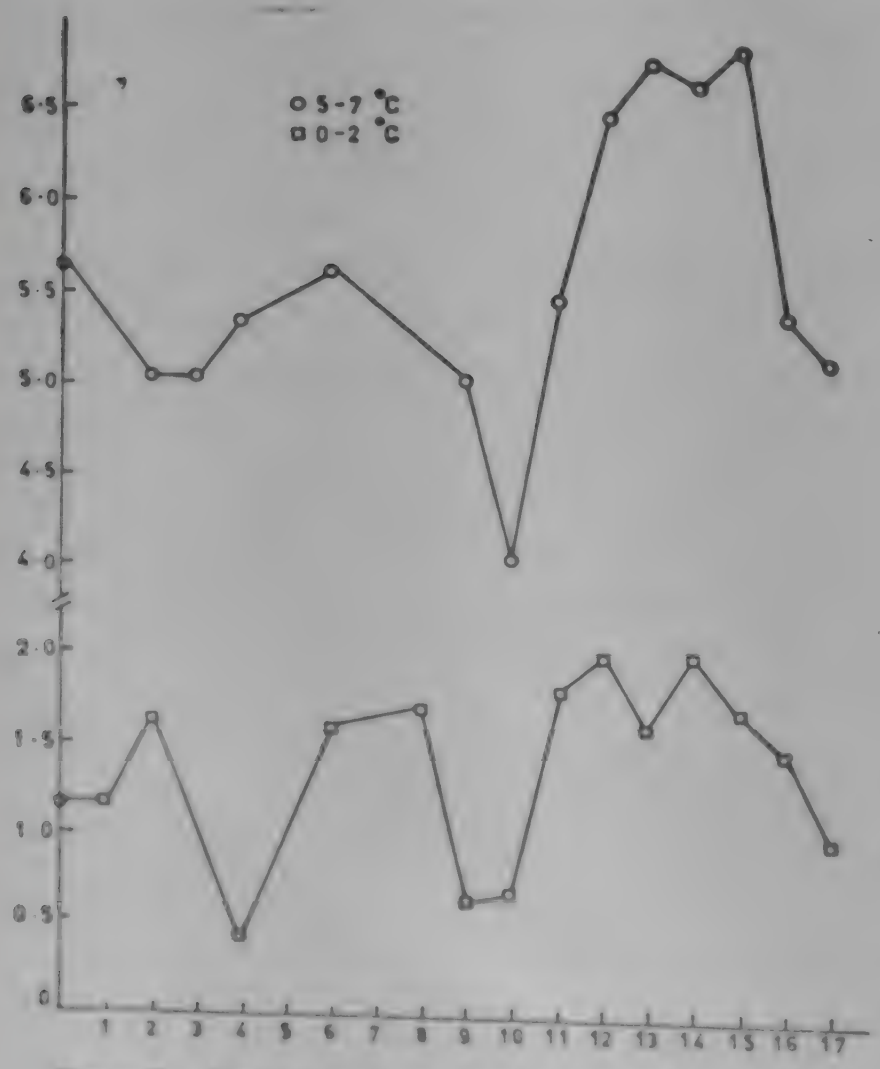

Figure 2. Temperature variation in the cabinet during Storage of Cod Fillets

Table 1. Chemical composition of cod fillet

Moisture	80.4%
Protein	18.1%
Lipid	0.7%
Ash	1.1%
Calcium mg/100 gm	20
Phosphorous mg/100 gm	200
Iron mg/100 gm	0.6
Iodine mg/100 gm	0.5

Table 2. Storage changes in cod fillets packed in controlled atmosphere and kept at 0-2°C

Days	Moisture	pH	TVN mg/100g sample	Total plate count/g sample
0	82.89	6.75	5.06	2.23×10^4
5	82.30	6.70	19.40	2.00×10^5
11	81.86	6.60	29.49	3.42×10^5
14	82.34	6.80	44.30	5.60×10^5
17	81.34	6.85	49.04	1.46×10^6
*19	82.00	6.90	65.45	1.70×10^6

*Spoiled at 19 days of storage at 0-2°C.

Table 3. Storage changes in cod fillets packed in Air at 0-2°C

Days	Moisture %	pH	TVN mg/100g sample	Total plate count/g sample
0	82.28	6.75	5.1	1.48×10^5
2	81.57	6.75	9.1	1.60×10^5
4	83.82	6.70	12.51	1.83×10^5
6	82.12	6.65	16.35	2.13×10^6
9	81.31	6.80	37.25	2.43×10^6
*11	82.00	6.85	69.71	9.2×10^6

*Spoiled at 11 days of storage.

Microbial growth was markedly inhibited by the presence of carbon dioxide and oxygen mixture in the packet. As a typical example, cod fillet held in gas mixture for 11 days had a microbial count of 342,000 compared to the value of 92,00,000 for that packed in air at 0-2°C. In all the samples PH decreased due to the production of lactic acid and

Table 4. Storage changes in gas packed cod fillets stored at 5-7°C

Days	Moisture %	pH	TVN mg/100g sample	Total plate count/g sample
0	82.89	6.75	5.06	2.23×10^4
7	81.63	6.70	69.53	2.82×10^5
*12	83.12	7.0	82.70	4.54×10^6

*Spoiled at 12 days of storage.

Table 5. Storage changes in cod fillets packed in Air at 5-7°C

Days	Moisture %	pH	TVN mg/100g samples	Total plate count/g sample
0	82.28	6.75	5.1	1.48×10^5
2	80.60	6.80	20.33	2.78×10^6
4	83.23	6.65	26.35	4.04×10^6
*6	82.00	6.90	72.00	1.01×10^7

*Spoiled at 6 days of storage at 5-7°C.

at the time of spoilage it approached the neutral. Also the amount of TVN produced is less in the gas packed sample stored for 11 days compared to air packed sample which is much higher. It has also been found that the cod fillets packed in controlled atmosphere exhibited only moderate off odour at the time of spoilage and they could be kept in acceptable condition for a period of 17-18 days at 0-2°C compared to 9 days in case of air packed sample at the same temperature. At the time of spoilage more drip was observed in the gas packed sample which was not however sufficient to create any toughness in meat.

The storage life of cod fillet stored at a temperature between 5-7°C are presented in tables 4 and 5. Microbial growth has been considerably retarded in CAP compared to air packed sample. As a typical example, cod fillet held in gas mixture for 7 days had microbial count of 2,82,000 compared to a value of 1,01,00,000 for the control (in air) after 6 days. The sample under controlled atmosphere packaging could be kept in acceptable condition for a period of 11 days at 5°C as against 5 days in the case of air packed sample. At the time of spoilage more drip was observed in the gas packed sample.

Conclusion

There is a significant increase in the storage life of cod fillets under controlled atmosphere packaging using PVC tray laminated with polythene. It is found that the extension of shelf life is dependent on storage temperature. It is unlikely that under commercial conditions, temperature can be controlled at exactly 0°C and therefore to achieve a useful extension of shelf life, it is recommended that the fish temperature be controlled between 0-2°C. In India controlled atmosphere packaging can be advantageously tried for highly priced fishes like Hilsa, Pomfret, Seer and Pearl spot.

Acknowledgement

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Corrosion of Aluminium Containers with Some Processed Food Products

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ABSTRACT

Aluminium cans are not highly resistant to corrosion by acid fruits and vegetables. Corrosion resistance is improved by anodizing and/or lacquering. Corrosion of aluminium cans does not produce coloured products as compared to tinplate can. Aluminium owes its corrosion resistance to the film of oxide on its surface. This oxide film is almost chemically inert and rapidly repairs itself if removed or damaged, as long as oxygen is available to reform the film. The corrosion reactions of aluminium, which are different from tinplate and the corrosion reactions which are special to aluminium, with remedies are discussed.

Introduction

As a packaging material aluminium has many advantages like light weight, good resistance to external corrosion, non-toxic, easy to work and attractive finish and recyclability. However its poor performance to internal corrosion restricts its usage in plain form.

The Oxide Film:

Aluminium is next only to magnesium in the galvanic series, and has a high free energy content. This means that it has a strong tendency to corrode. But it has a fair resistance to corrosion due to the presence of passive oxide film of about 50 A°. Thus the corrosion resistance of aluminium depends upon the resistance of the oxide film rather than the metal itself.

Non-Toxicity:

Aluminium dissolved in foods is non-toxic. It is very widely distributed in nature and occurs in majority of foods[1] and also in human organism[2].

Beef	1-8	ppm			
Onions	90	"	Brain (human)	0.04	ppm
Potatoes	76	"	Lungs "	59	"
Carrots	22-30	"			

It has been confirmed that there is no significant accumulation of aluminium in human organism from the amounts likely to be found in food[1]

Corrosion Resistance of Aluminium:

In general Aluminium has a fair resistance to corrosion and acidity is the main controlling factor. For unprotected aluminium, pH should not be less than 5.2. As corrosion accelerators, the influence of oxalates is more than hydroxy acids (tartaric, malic, citric), presence of chlorides leads to pitting. Sugar reduces corrosion in the products like jams and jellies[4].

Corrosion reactions of aluminium that are slightly different from tinplate:

1. *Hydrogen Evolution:*

The dissolution of aluminium is accompanied by hydrogen evolution. One mg of aluminium dissolved in acid or alkali liberates approximately one ml of hydrogen at normal temperature and pressure. Thus the solution of 20-30 mg of aluminium dissolved is accompanied by hydrogen enough to produce a hydrogen swell whereas in a tinplate can ten times this amount may not produce swelling. Thus vacuum loss is more in aluminium cans as compared to tinplate cans and many researchers[5-7] have employed vacuum loss as the criteria for evaluation of corrosion.

2. *Corrosion with Sulphur Containing Products:*

Aluminium does not produce dark sulphur stains with sulphur containing products like tinplate. This is because of the instability of aluminium sulphide.

The traces of hydrogen sulphide can be smelt as soon as the can is opened.

3. Bleaching:

Aluminium has a greater tendency to bleach the highly pigmented products than tin. The pinkish tinge of shrimps packed in plain aluminium cans turns grey. The bleaching is a result of more evolution of hydrogen compared to tinplate cans. Bleaching can be avoided by lacquering. Surprisingly, whole Kernel Corn retained a brighter yellow colour in uncoated aluminium cans, than in tinplate and aluminium containers that had an internal coating[6].

Corrosion reactions that are specific to aluminium[8]

(i) Contact Corrosion:

In the early days tinplate trays were used for placing aluminium cans. When the cans were left in the trays overnight, there used to be a severe pitting with these aluminium cans. This is due to the formation of galvanic cell with aluminium as anode and tray as cathode and residual content in the tray as electrolyte. Now aluminium trays are employed for aluminium cans.

(ii) Copper Corrosion:

This happens when aluminium comes in contact with copper salts introduced from defective cooking utensils of tinned copper or from vegetables coloured by copper salts. Elemental copper deposits on aluminium forming local cell and a strong corrosion will follow.

(iii) Fat Corrosion:

This was observed with meat products. During processing the fat in the meat melts and floats over the surface forming a solid layer of fat. Strong corrosion under the fat layer with the liberation of hydrogen was observed. It is not the fat that is corrosive as pure fat can be successfully packed in aluminium cans. Though this corrosion is explained as a consequence of differential aeration cell formation, it has not been theoretically studied yet. However the latter two forms of corrosion can be avoided by lacquering.

Corrosion Preventive Measures:

1. Anodizing
2. Bohmite film formation
3. Lacquering
4. Alloying

1. Anodizing:

The thickness of passive aluminium oxide film can be increased by anodizing. The anodized film is associated with pores and the pores should be sealed to get corrosion resistance. This is done by holding the cans in boiling water or steam. By this treatment the aluminium oxide gets converted into more bulky aluminium hydroxide. The thickness of the anodized film varies from 2-6 μ.

2. Bohmite Film[7]:

It resemble anodic film. Bohmite is a crystalline oxide of aluminium produced when the metal is boiled in water or exposed to steam. The addition of ammonia triethanolamine increases the rate of formation of the film. The film thickness is of the order of 0.5-1.0μ. This method is not commercially used for protecting food cans.

3. Lacquering[7]:

Lacquering is done by spraying the inside surface of cans with lacquer and then baking. Some lacquers adhere well to aluminium cans. The adhesion of lacquer can be improved by a pretreatment before lacquering. This pretreatment may be as forming the anodic film or conversion coatings (by employing chemical solutions). The lacquering can be done after anodizing for two advantages. First the lacquer itself will seal the pores of anodized film (eliminating one step in anodizing) and second the lacquer will have a good adhesion over the rough surface because of good anchoring.

Epoxy phenolic lacquers provide good corrosion resistance and adhere well to aluminium even without pretreatment. For colourless lacquers epoxy amines can be used, but they are less resistant than epoxy

Table 1. Shelf-life of various products packed in lacquered cans[7]

Food Product	Time to reach 25%H_2 swell at 35°C	Shelf-life at room temp (25-30°C)
Beans in tomato sauce	19 months	about 4 years
Garden peas	more than 4 years	more than 12 years
Carrots	3 years	7 years
Apricot pulp	10 months	2 years
Tomato pulp	14 months	$2\frac{1}{2}$-3 years
Evaporated milk	2 years	6-8 years
Beer	—	more than 1 year

phenolics. Solution vinyls are free from the risk of giving off-flavours but they need pretreatment for adhesion, and are permeable to moisture. Modified vinyls are less permeable but not so free from flavour problems. When pigmented with titanium dioxide they are both protective and clean in appearance. The shelf-life of various products packed in cans sprayed with epoxy phenolic lacquers is shown in table-1.

Carrots, beans, potatoes in brine canned in lacquered aluminium cans at C.F.T.R.I. kept well for more than 6 months at 37°C[9].

4. Improvement by alloying[10]*:*

Magnesium being next (above) to aluminium in the galvanic series, alloying with magnesium does not impart galvanic corrosion. Infact magnesium has a benificial influence and increases corrosion resistance.

Manganese slightly increases corrosion resistance. Chromium at 0.1-0.2% level increases corrosion resistance. Silicon slightly decreases corrosion resistance, its effect depends on its form and its location in the microstructure of alloy.

Copper as already mentioned reduces the corrosion resistance, and more than any other alloying element it leads to higher rate of general corrosion, a greater incidence of pitting.

In India prospects for introduction of aluminium cans for packing food products appears to be good because of availability of bauxite. A few manufacturers have come forward to manufacture aluminium cans for packing food products. A project has been initiated at CFTRI to study the corrosion behaviour of aluminium cans with some model solutions and to find the suitability of aluminium cans for packing some of the non-acid food products. These studies are in progress[9].

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Metal Pickup in Plain and Lacquered Tinplate Containers with Processed Food Products

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ABSTRACT

Normally in a tinplate container tin acts as a sacrificial anode to protect the base steel plate. Mechanism of corrosion differs between plain and lacquered cans. The dissolution of tin and iron in plain and lacquered cans with some commercially important fruit and vegetable products have been studied during storage. The dissolution of iron was found to be more in lacquered cans as compared to plain cans.

Introduction

Details of different types of lacquer[1], its screening for food products[2] and its safety aspects[3] have been reported earlier.

It is well known that in a plain tinplate can tin acts as anode (sacrificial) and protects the iron (baseplate), thus ensuring the very structural material of the can remaining intact. In lacquered tinplate containers lacquer serves as a barrier between the can metal and the contents and thus reduces overall corrosion considerably. But at scratches and defects, the corrosion concentrates i. e., localised corrosion takes place which may sometimes lead to pitting. The lacquer prevents the free anodic action of tin as it covers up tin. Thus there is more iron pickup in lacquered cans as compared to plain cans. The mechanism of corrosion based on metal pickup is discussed in this communication.

Corrosion Fundamentals

The main difference between the corrosion in plain and lacquered cans is;

(i) in plain can the anode area is large and is more than cathode area as tin is anodic and iron pores are cathodic. Thus the corrosion is almost uniformly distributed throughout the can/content interface.

(ii) in lacquered cans by virtue of permeation of dissolved oxygen and probably proton the entire plate acts as cathode for a very small anode area at the scratch. Thus the corrosion is concentrated at the scratch and a localised corrosion will follow.

The attack on the scratch can be of two ways[4]

(1) Corrosion in depth

The scratch as anode and tin in the vicinity as cathode, the corrosion proceeds in depth and perforates the can. This occurs when products contain anode depolarisers (discussed later in detail).

(2) Corrosion in breadth

The corrossion after a certain depth of attack exposes more tin and tin acts as anode and corrosion proceeds in breadth under the film. If this corrosion proceeds more, the tin which is holding the lacquer dissolves and lacquer starts to peel off.

Permeability of Lacquers

In the plain can also initially iron will be anode and tin will be cathode. But in lacquered cans this continues as the tin is covered by lacquer preventing it to function as anode, yet permitting it as a cathode (by its permeability to cathode depolarisers like oxygen and, proton). It is considered that under these circumstances the first function of tin is to provide a depolarising cathode in the form of its oxide film. When corrosion begins at deep scratch it is seen to spread beneath the lacquer when normally bright tin surface becomes dull grey. The loosening of lacquer from this dull grey surface may be thought to be a simple result of dissolution of metallic tin (i.e., tin functioning as anode) but it is evident that anodic attack has been concentrated on the exposed steel at the site of original scratch (i.e., iron functioning as anode)[5].

To explain this, it is considered that tin oxide film functions as depolarising cathode initially and reduction of this oxide film by nascent hydrogen probably destroys the bond responsible for the the adhesion of the lacquer film over this area as a result of which, the lacquer peels away from the tin on both sides of the scratch. This exposes more tin surface and is probably followed by local action on tin.[6]

Hydrogen Evolution

Dissolution of 3 mg. of iron leads to one ml. of hydrogen formation at normal temperature and pressure in the absence of hydrogen acceptors. But though hydrogen evolution is little more than in plain can, measurable hydrogen is always much less than the equivalent of the metals dissolved.

To explain this low measurable hydrogen and loosening of lacquer film from the tin surface (with tin functioning as cathode) Cheftel et al[6] represented the series of reactions schematically as follows:

$$Sn \rightarrow Sn^{++} + 2H$$
$$\rightarrow Sn(OH)_2 \rightarrow Sn$$

This kind of reaction is going on in the plain can. The hydrogen evolved in the first step (dissolution of metal) is oxidised to water in the second step (forming elemental tin) and net equivalent of hydrogen evolved is nil.

In the case of scratch in a lacquered can, the Fe, Sn and $Sn(OH)_2$ are exposed in close proximity, and the reaction that is taking place could be written as:

$$Fe \rightarrow Fe^{++} + 2H$$
$$Sn(OH)_2 + 2H \rightarrow Sn + 2H_2O$$

These are oversimplified schemes, yet it can tell the major corrosion reactions involved.

Repassivation

The redoposition of the tin on the scratch itself is termed as repassivation effect. This can be demonstrated by dipping a scratched lacquered tin plate in oxygen free acid solutions containing dissolved tin for some time. Here tin from the dissolved phase deposits on the scratch (unlike the scheme mentioned above wherein tin is formed from the reduction of tin oxide), covering it as a barrier to some extent and providing cathodic protection to the pore.

Effect of Corrosion accelerators

In a lacquered can, if we accept the hypothesis that there are abundent depolarisation mechanisms for the cathode like permeability of lacquer film to oxygen and proton it follows that the corrosion at pore (ie, exposed steel base) is most probably controlled by anodic polarisation. But any reaction which depolarises the anode will be detrimintal to the can itself. It is found that stone fruits such as cherries and plums sometime corrode the lacquered cans with unexpected severity because of presence of β-glucosidase and glycoside amygdalin. It is known that β-glucosidase activity in stone kernels results, in the liberation of small quantities of hydrogen cyanide (of the order 4-5 mg/kilo) and it is supposed that this substance acts as an anode depolariser of the iron. If the stones are removed before canning or if the heat process given to the canned fruit is sufficient to inactivate the enzyme then accelerated carrosion does not occur. The accelerated corrosion with continued β-glucosidase activity does not apply to the corrosion in plain cans as corrosion in plain cans are not controlled anodically[7].

Though the anodic depolarisers are the important cause of accelerated corrosion, it cannot initiate the corrosion. A perfect lacquer barrier would therefore be a proof against such corrosion.

To summarise, the anodic depolarisers are detrimintal to the can whereas the cathodic depolarisers are not. Our studies with the product Kundri (ivy gourd, which contains the cathodic depolariser-nitrate ions) showed that the product could keep well in lacquered cans as corrosion in lacquered cans are controlled anodically[8].

The studies on other factors like the minimum dissolved tin required to prevent iron dissolution in lacquered cans[9] and effect of particle size of tin powder in lacquared cans to prevent iron dissolution[10] have been reported.

To put in a nutshell, the complexity of corrosion in lacquered cans is much more than plain cans and hence the variation of corrosion from can to can is much more than in plain cans.

Metal Pickup in canned fruit and vegetable products:

Tin and iron pickup in some canned fruit and vegetable products during storage has been studied and the results are incorporated in table 1. Tin con-

Table 1. Metal Pickup in canned fruit and vegetable products

Product	Type of can	Storage Period (Months)	Tin (PPM)		Iron (my/100 gm)	
			RT	37°C	RT	37°C
Mango Juice	Plain	6	84	143	2.3	3.7
	Polyester lacquered	6	49	63	1.7	2.9
	Epoxy-Phenolic (fruit) lacquered	6	53	72	3.3	3.1
Papaya slices	Plain	6	67	—	2.0	—
	Polyester lacquered	6	39	—	1.4	—
	Epoxy-Phenolic (fruit) lacquered	6	36	—	3.0	—
Potato slices	Plain	9	173	375	2.37	2.4
	Polyester lacquered	9	117	95	1.74	13.7
	Epoxy-Phenolic (Vegetable) lacquered	9	139	80	2.6	2.3
Kundri (Ivy gourd)	Plain	6	600	—	6.4	—
	Polyester lacquered	6	112	—	7.1	—
	Epoxy-Phenoli (Vegetable) lacquered	6	129	—	6.8	—

tent was more in plain cans than in lacquered cans in all the products tried as expected. Generally iron content is more in lacquered cans as compared to plain cans.

It can be readily seen in these results that in some lacquered cans there is not much increase in the metal pick up when stored at higher temperature and in some high metal pick up even at lower temperature. Thus the corrosion is highly individualised to a particular can. To have a firm opinion on the corrosion mechanism the study needs isolation of all corrosion parameters in different model systems with quantisable lacquer defects and in large numbers. With no defects in the lacquer there will be no corrosion at all even with systems with anodic depolarisers and other complexities. It is All or Nil type corrosion (All referring to number of variety of complex corrosion reactions and not the amount of corrosion). Thus, in the absence of defects lacquered can is an ideal container with respect to corrosion. Thus it can be said that with the lacquer assured as taint proof, it is the lacquering which is of paramount importance.

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Recent Trends in Packaging of Oils in Flexible Consumer Packages

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ABSTRACT

In recent years retail distribution of oils in unit consumer flexible pouches has drawn considerable attention of Government agencies and oil industries due to logistic advantages such as low cost, tailor made functionality, light weight etc. Storage studies of refined groundnut oil packed in different flexible unit packs and stored under different climatic conditions have been carried out. At 65% RH and 27°C oil with initial PV of 5 meq of O_2/Kg of fat, packed in films of polyolefins such as LDPE, HDPE and HMHDPE had a shelf life of 45 days. The keeping quality was found to be better in laminate pouches made of—polyester, nylon, Alfoil, laminated to PE or surlyn and also in HDPE bottles, and the shelf life ranged from 120 to 150 days. Under accelerated temperature of 40°C, the shelf life was 20 days in polyolefins and ranged from 60-80 days in laminate pouches. Whereas the oil with initial PV of 1 meq of O_2/kg of fat packed in polyolefins pouches had shown a shelf life of 80 days at IS condition and 40 days in accelerated condition. Only slight increase in FFA values during storage was noticed.

Studies on grease resistance of the films have indicated the superiority of HDPE and other laminate pouches for offering greater grease resistance (more than three times) as compared to LDPE through which considerable seepage of oil takes place within short time. Drop impact tests on filled pouches have indicated poor impact strength for HDPE as against good impact for LDPE and laminates based on polyester/polythene. All the flexible materials have also been evaluated for the safety of use for packaging of oils by overall migration tests using heptane as fat simulating solvent and were found to have extractive values below the specified limits.

Introduction

In India 34-38 lakh tonnes of vegetable oils are consumed per annum, out of which only 25-26 lakh tonnes are produced in the country and rest being imported[1]. Bulk quantities of oil are being distributed and transported in tin containers and galvanised iron drums. However, in recent years, due to escataling prices of metal containers, search is being made by oil industries for newer and economical alternative packaging media. Also in recent years, retail distribution of oils and fats in consumer unit packs are increasingly becoming popular as it assures quality and hygienic product. Even here, due to increasing costs and non-availability of metal containers, plastics have made significant inroads in retail distribution in unit consumer packs. Plastics in semirigid and flexible forms are becoming more popular due to logistic advantages such as low cost, tailor made functionality, light weight etc. The trends towards light weight plastic bottles and flexibles will increase in future years and search will continue to seek newer plastic materials which maximise protection at the minimum cost. In this paper studies carried out to assess the suitability and safety of different flexible consumer packages for packaging of oils are presented.

Materials and Methods

1. *Refined groundnut oil :* Refind groundnut oil packed in 16.5 kg. tin containers, purchased from the local market was used in the investigation. Two types of oils with initial perioxide value (PV) of 5 and 1 meq of 02/kg. of fat were used.

2. *Packaging materials:* Considering the physico-chemical attributes of the packaging materials and also the product deterioration charactristics, such as rancidity[2] the following packaging materials were

selected for carrying out storage studies. Unit pouches of size 140 mm×160 mm to hold 500 gm of oil were made by heat sealing at optimum temperature, pressure and time conditions from the following packaging materials.

(i) Low density polythene (LDPE) 300 & 500 gauge

(ii) High density polythene (HDPE) 500 gauge

(iii) High molecular, high density polythene (HM HDPE) 200 gauge

(iv) Coextruded (LD/HD) 450 gauge.

(v) Nylon/surlyn ionomer coextruded film

(vi) Polyester 12 μm/polythene 75 μm

(vii) Standup pouches (metallised polyester 12 μm/polythene 75 μm

(viii) 4-ply laminate (paper 60 gsm/polythene 120 gauge/Al. foil 0.009 mm/polythene 120 gauge.

(ix) HDPE bottles.

3. Estimations:

(i) Moisture content (MC)[3] was determined by drying 10 gm of sample in an oven at 105°±1°C for one hour.

(ii) Peroxide value (PV) and Free Fatty Acid value (FFA) were determined by standard Lea's method[4] and AOCS[5] method respectively.

(iii) Acceptability of the product during storage was judged by a panel of ten judges working in the laboratory, who evaluated the product for changes in colour, odour and rancid flavour.

4. Storage Studies: 500 g. unit pouches filled with the product and heat sealed were exposed to the following storage conditions.

(i) 92% RH & 38°C (Accelerated condition)

(ii) 30-40% RH & 40°C (dry accelerated condition)

(iii) 65% RH & 27°C (IS condition)

The samples were withdrawn periodically from each condition and analysed for chemical characteristics like PV, FFA & MC and they were also evaluated for their acceptability. The stored product was compared with control sample kept in refrigerator. The results are presented in Table. 1 & 2.

5. *Drop impact strength:* of the pouches were assessed by determining the number of drops withstood by dropping 500 g. unit pouches filled with water from 90 cm. height on a hard concrete surface. The results of the study are presented in Table 3.

6. *Grease resistance test:* Six unit packs of 50 g. of size 60 mm×100 mm. containing ground nut oil coloured with 0.1% sudan red dye, were placed over white sheet of paper at two different temperatures of 40°C & 27°C. The seepage of the oil through the surface of the pouch was observed by periodically watching for the appearance of red stains on white paper below each pouch. The number of days required for the appearance of the red stain on the paper was taken as the time required for oil transduation through the surface of the film. The results are presented in Table 3.

7. *Migration test:* In order to assess the safety of use of the above packaging materials for packing of oils, overall migration tests were carried out using pouch method in which 500 cc. of fat simulating solvent heptane was exposed to 49°C (120°F) for 15 minutes and the amount of extraction obtained from unit packs was determined as per code of Federal regulation[6]. The amount of the extractive expressed as mg/sq. in of the material and also as ppm based on water capacity of the pouch is presented in Table 3.

Results and Discussion

1. *Storage studies:*

(i) At 92% RH & 38°C: As can be seen from table 1 & 2 oil with an initial PV of 5 meq of O_2/kg. of fat packed in LDPE 300 & 500 gauge, HDPE, HMHDPE pouches was acceptable at the end of 20 days with a PV of 21, whereas it was not acceptable at the end of 40 days when PV crossed 48. On the other hand the oil with PV of 1 meq of O_2/kg. of fat packed in above pouches was acceptable at the end of 40 days of storage with PV 22 and not acceptable at the end of 60 days, when PV in the above pouches crossed 40. Further, this oil packed in coextruded HD/LD and HDPE bottles was acceptable for 40 & 80 days with PV 22 & 16.3 respectively and was not acceptable at the end of 60 days and 100 days with corresponding PV of 39 and 37 respectively.

Oil with PV 5 packed in laminate pouches of polyester/poly. & Standup pouch (metallised polyester/poly), although was acceptable with respect to

Table 1. Physico-Chemical Changes and Acceptability of Refined ground Nut Oil during storage under different conditions in Flexible Packages

Packaging materials	No. of days	92% RH & 38°C				30-40% RH & 40°C				65% RH & 27°C*			
		PV	FFA	MC	Remarks	PV	FFA	MC	Remarks	PV	FFA	MC	Remarks
LDPE (300 gauge)	20	21(6.8)	.13(.11)	.09(.17)	A(A)	20(8.1)	.12(.11)	.06(.06)	A(A)	12(1.1)	.11(.11)	.06(.08)	A(A)
	40	52(22.1)	.15(.13)	.11(.2)	NA(A)	69(32.7)	.16(.11)	.07(0.9)	NA(NA)	25(6.4)	.12(.11)	.08(.08)	JA(A)
	60/70*	(46.4)	(.15)	(.21)	(NA)					38(11.1)	.12(.13)	.08(.08)	NA(A)
	80/90*									(22.5)	(.14)	(.08)	(A)
LDPE (500 gauge)	20	20(6.7)	.13(.11)	.09(.16)	A(A)	18(8.1)	.12(.11)	.06(.07)	A(A)	10(1.1)	.11(.11)	.06(.08)	A(A)
	40	48(20.4)	.15(.12)	.1(.2)	NA(A)	60(30.6)	.15(.11)	.08(0.08)	NA(NA)	24(6)	.12(.11)	.08(.08)	JA(A)
	60/70*	(41.2)	(.15)	(.22)	(NA)					32(11.2)	.12(.12)	.09(.08)	NA(A)
	80/90*									(22.5)	(.14)	(.08)	(A)
HDPE (500 gauge)	20	18(6.8)	.13(.11)	.09(.16)	A(A)	16(9.9)	.12(.11)	.06(0.7)	A(A)	8.5	.11	.06	A
	40	59(20.4)	.15(.12)	.09(.2)	NA(A)	52(34.2)	.15(.11)	.09(.09)	NA(NA)	19	.12	.06	A
	60/70*	(39.8)	(0.15)	(.23)	(NA)					31	.12	.07	NA
HM-HDPE (200 (gauge)	20	21(7.2)	.13(.11)	.09(.19)	A(A)	19(14.7)	.12(.11)	.06(.07)	A(A)	9(1.3)	11(.11)	.06(.08)	A(A)
	40	54(20.4)	.16(.12)	.08(.2)	NA(A)	68(37.7)	.16(.11)	.07(.08)	NA(NA)	22(5.5)	.12(.11)	.09(.09)	A(A)
	60/70*	(42.1)	(.15)	(.2)	(NA)					28(8.8)	.12(.13)	.08(.09)	NA(A)
	80/90*									(16)	(.14)	(.09)	(A)
COEXTRUDED HD/LD (450 gauge)	20	(6.7)	(.11)	(.15)	(A)	(9)	(.11)	(0.08)	(A)	(1)	(.11)	(.08)	(A)
	40	(22.2)	(.11)	(.2)	(A)	(27.2)	(.11)	(.08)	(NA)	(15)	(.12)	(.08)	(A)
	60	(39.3)	(.15)	(0.2)	(NA)					(7.5)	(.13)	(.08)	(A)
	80									(14.8)	(.14)	(.08)	(A)
	100									(21.2)	(.18)	(.08)	(A)
	120									(32.6)	(.18)	(.09)	(NA)
HDPE Bottles	20	(4.9)	(.11)	(.14)	(A)	(5.3)	(.11)	(0.07)	(A)	(1)	(.11)	(.08)	(A)
	40	(9.2)	(.11)	(.15)	(A)	(10.6)	(.11)	(0.08)	(A)	(5)	(.12)	(0.7)	(A)
	60	(9.4)	(.11)	(.18)	(A)	(14.2)	(.11)	(.08)	(A)	(5.5)	(.12)	(.07)	(A)
	80	(16.3)	(.16)	(.18)	(A)	(24.4)	(.14)	(.08)	(JA)	(11.5)	(.13)	(.09)	(A)
	100	(36.8)	(.19)	(.17)	(NA)	(36.6)	(.18)	(.09)	(NA)	(14.8)	(.15)	(.09)	(A)
	120									(24.7)	(.15)	(.09)	(JA)

Initial analysis: PV: ==5.1(1) meq of 02/kg. of fat.
FFA:=.11 (.11) as % oleic acid
M.C.=(.08) as % by wt.

Note. Bracket values are for sample with initial PV of 1, whereas values without brackets are for sample with initial PV of 5.
*Number of days only for samples without bracket. at 65% RH & 27°C

Table 2. Physico-Chemical changes and Acceptability of refined ground nut Oil during storage under different conditions in flexible Packages

Packaging Materials	No. of days	92% RH & 38°C				30-40% RH & 40°C				65% RH & 27°C*			
		PV	FFA	MC	Remarks	PV	FFA	MC	Remarks	PV	FFA	MC	Remarks
Polyester 12 μ / LDPE	40	14	0.15	0.1	A	7	0.13	0.08	A	10	0.12	0.08	A
300 gauge	60/70*	19	0.15	0.11	A	16	0.13	0.08	A	16	0.12	0.07	A
	80/90*	22	0.15	0.13	A+	26	0.14	0.08	JA	17.7	0.12	0.07	A
	100/120*	26.5	0.16	0.14	NA+	27.4	0.14	0.09	NA	23.5	0.13	0.08	A
	120/140*									24.8	0.13	0.08	JA
	140/160*									27.4	0.14	0.08	NA
Stand-up pouch	40	4	0.15	0.12	A	4	0.13	0.06	A	4	0.12	0.07	A
Metallised PET 12 μ /PE	60/70*	4	0.15	0.12	A	4	0.13	0.07	A	4	0.12	0.08	A
300 gauge	80/90*	4.2	0.15	0.11	A+	3.5	0.14	0.08	A	4.4	0.12	0.07	A
	100/120*	4.2	0.15	0.13	A+	4.2	0.14	0.07	A	5.2	0.13	0.09	A
	120/140*									13.3	0.13	0.08	A
Nylon/Surlyn	40	15	0.15	0.09	A	8.5	0.13	0.08	A	5	0.12	0.08	A
	60/70*	22	0.15	0.11	A	8.7	0.13	0.06	A	8	0.12	0.08	A
	80/90*	27	0.15	0.12	NA+	9	0.14	0.08	A	8.9	0.12	0.07	A
	100/120*					9.1	0.14	0.08	A	14.7	0.12	0.07	A
	120/140*					13.8	0.14	0.08	A	15.9	0.12	0.08	A
	140/160*					19.5	0.14	0.08	A	16	0.14	0.09	A
	160					38	0.15	0.08	NA				
Paper/A1. Foil/LDPE	40	5	0.14	0.08	A	4.3	0.13	0.09	A	4	0.12	0.09	A
40GSM/.009mm/150 gauge	60/70*	5	0.14	0.08	A	3	0.13	0.08	A	4	0.12	0.08	A
	80/90*	7	0.14	0.08	A	4	0.14	0.08	A	5.8	0.12	0.08	A
	100/120*	7	0.15	0.11	A	2.5	0.14	0.08	A	6.9	0.12	0.08	A
	120/140*					4.7	0.14	0.08	A	10.6	0.12	0.08	A
	140/160*					4.9	0.14	0.09	A	10.6	0.13	0.09	A
	160					8.9	0.14	0.08	A				
		Control at Refrigerator											
Glass bottles	40	6	0.12	0.07	A	3.8	0.14	0.06	A	5	0.12	0.08	A
	60/70*	7	0.12	0.07	A	6	0.14	0.07	A	4	0.12	0.07	A
	80/90*	7	0.12	0.08	A	9	0.14	0.07	A	4.8	0.12	0.07	A
	100/120*	8	0.12	0.08	A	2.2	0.14	0.08	A	7.3	0.12	0.08	A
	120/140*	8	0.12	0.08	A	3.1	0.14	0.08	A	12.4	0.12	0.08	A
	140/160*	9.2	0.12	0.08	A	4.4	0.14	0.08	A	11.5	0.12	0.08	A
	160	9.5	0.12	0.08	A	5.3	0.14	0.08	A				

*No. of days at condition 65% RH & 27°C
†Cloudiness at this period

rancid odour at the end of 80 days with PV of 22 & 4.2 respectively, it was not acceptable because of cloudiness in the samples which may be due to moisture ingress. The product in Nylon/surlyn pouches was acceptable for 60 days with a PV of 22 and was not acceptable at the end of 80 days with a PV of 27. The product packed in 4 ply laminate of paper/poly/foil/poly kept well even at the end of 100 days having hardly a PV of 7.

FFA value expressed as per cent oleic acid has shown a slow and gradual increase in all the packages. The maximum FFA value reached was 0.15 as against initial value of 0.11 in both types of oils at the terminal storage-life. Also under this high humid condition, steady increase in moisture was observed in all packages. From the initial value of 0.06%, it reached a maximum value of 0.2% which was more than the PFA specified limit[7] of 0.1%.

(ii) 30-40% RH & 40°C: The product packed in polyolefins was acceptable for 20 days in both types of oils with PV reaching to 20 and 14 respectively. However, at the end of 40 days the two types of oil were not acceptable with PV crossing 50 in first type and 30 in the other one. The product with PV of 1 packed in coextruded HD/LD & HDPE bottles was acceptable at the end of 20 and 80 days with corresponding PV of 9 & 24 respectively and at the end of 40 and 100 days the product with PV of 27 and 36 respectively was not acceptable.

The product with initial PV of 5 packed in polyester/poly and Nylon/surlyn was acceptable at the end of 80 and 140 days, PV reaching to 26 and 19 respectively. The product was still acceptable in standup packs, foil based laminate pouch and HDPE bottles at the end of 100, 160, 160 days with PV of 4.2, 9 & 5 respectively.

Practically no change in moisture and slight change in FFA was observed in all the packages at terminal storage periods.

(iii) 65% RH & 27°C: Oil with PV of 5 packed in polyolefin film pouches was acceptable at the end of 40 days. The maximum PV of 25 was observed in 300 gauge LDPE pouches where it was just acceptable with respect to rancid odour. At the end of 70 days, PV was more than 28 in the above packages and the product was not acceptable by the panel of judges. However, the product with PV of one packed in above polyolefin pouches was acceptable at the end of 80 days, PV being less than 22. The same oil packed in coextruded HD/LD and HDPE bottles was acceptable upto 100 days and 120 days, PV being 21 & 25 respectively.

The product with PV of 5 packed in laminate pouches such as, stand up pouches, Nylon/surlyn, paper/poly/foil/poly and HDPE bottles was found acceptable even at the end of 160 days, maximum PV reached being 16. In polyester/poly packs the product had a PV of 24.8 and was just acceptable at the end of 140 days.

The FFA increased slowly during storage and reached a maximum value of 0.18 at the end of 160 days and the m.c. remained practically constant during storage.

2. *Grease Resistance test:*

As can be seen from table 3, the oil oozes through the surface of low density polythene (300 & 500 gauge) pouches in 7 days at 40°C and in 30 days at 27°C. Further, the pouches were sticky due to oozing of oil. However, in HM-HDPE, HDPE and coextruded HD/LD pouches the seepage at 40°C was observed in 20, 20 and 70 days respectively. At 27°C in HM HDPE pouches it oozed out at 60 days and in HDPE it did not seep even at the end of 180 days. In all the laminate pouches the seepage was not observed even after 180 days in both conditions of 60°C and 27°C. Hence shelf-life of the product can be limited to 7 days at accelerated conditions & 30 days at IS condition in LDPE pouches.

Thus, from the results obtained it can be inferred that LDPE as can be expected has poor resistance to oil seepage as against better performance by HDPE, HMHDPE and other laminate pouches in which LDPE is inner layer.

3. *Drop Impact test:*

The best performance in drop impact strength was by LDPE pouches (both 300 and 500 gauge). These pouches withstood about 20-25 drops from a 90 cms height. The next best was polyester/poly & Nylon/Surlyn laminate pouches which withstood 5 drops with no air space inside the pouch and 18 drops with 25% air inside. The other films and laminate pouches broke in one drop itself suggesting their poor performance in withstanding drop impacts.

4. *Migration test:*

With respect to the safe use of these packaging materials for packing of oils, overall migration tests

Table 3. Values for Impact strength, Grease Resistance & Migration test on different packaging materials

Packaging Materials	Impact strength No. of drops 30 cm. ht.	Grease Resistance (days) 27°C	40°C	Migration-Extractive Mg/sq. in	Heptane values ppm
LDPE 300 gauge	25	30	7	0.17	22
LDPE 500 gauge	18	30	7	—	—
HDPE 500 gauge	1	180	20	0.014	2
HM-HDPE 200 gauge	1	60	20	0.035	5
HD/LD Coextruded film 500 gauge	1	180	70	0.038	6
Polyester/poly	5 (18 with 25% air)	180	180	0.076	10
Stand-up pouch (metallised polyester/poly)	—	180	180	0.09	12
Nylon/Surlyn	>5	180	180	0.098	12
Paper/poly/Al. foil/poly	2	180	180	0.09	12

have been carried out with heptane under accelerated condition of extraction of 49°C (120°F) for 15 minutes and the results expressed as ppm and mg/sq. in. are presented in Table 3. As can be seen the total migration from all packaging materials used was less than the FDA specified limit of 50 ppm or 0.5 mg/sq. in. The Maximum extractive values were obtained for LDPE i. e. 22 ppm or 0,17 mg/sq. in. and the least was for HDPE i. e, 2 ppm or 0.014 mg/sq. in. The results suggested that the films and laminates used in the study are having the overall migration values less than the stipulated value for the intended use of packaging of oils and fats.

Conclusion

From the storage studies made, the following inferences can be drawn:

1. Development of PV of 25 meq of oxygen/kg. of fat appears to be critical with reference to the acceptability of the refined groundnut oil. Similar observations have also been made by Usuf Ali et al[8] for raw sunflower oil and groundnut oil and by Balasubrahmanyan et al[9] for salted spiced peanuts.

2. At 65% RH 27°C refined groundnut oil with an initial peroxide value (PV) of 5 meq of oxygen/kg. of fat packed in film pouches of low density polythene (LDPE), high density polythene (HDPE) and high molecular high density polythene (HMHDPE) has a shelf life of 40 days. The keeping quality was better in laminate pouches made of polyester, nylon, and aluminium foil laminated to polythene or surlyn and also HDPE bottles and the shelf life ranged from 120 to 160 days. Under accelerated condition of temperature of 40°C, the shelf life was hardly 20 days in all polyolefin film pouches (LDPE, HDPE & HMHDPE) & 80 to 140 days in laminate pouches. On the otherhand the oil with initial PV of 1 meq of oxygen/kg. of fat packed in polyolefin pouches had a shelf life of 80 days at IS condition of 65% RH & 27°C and 40 days in accelerated condition of 22% RH & 38°C. Thus, the results clearly indicate that initial PV of oil at the time of packaging has pronounced effect in increasing the shelf life of the product, packed in polyolefin film pouches.

3. During storage FFA value of oil increases only slightly under all conditions of storage and the maximum change noticed at 92% RH and 38°C is also within the maximum specified limit of 0.25% by PFA[7].

Even moisture content in oil increased slightly at 92% RH & 38°C condition only and remained practically same as initial in other two conditions.

4. Studies on grease resistance of the films and laminates used suggests the superiority of HDPE & other laminate pouches for offering greater grease resistance i. e, more than three times, as compared to LDPE through which considerable seepage of oil takes place within 7 and 30 days at 40°C and 27°C respectively.

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5. Drop impact tests on water filled pouches suggests poor impact strength for HDPE HM-HDPE packs as against good impact for LDPE polyester/ poly laminate pouches.

6. Overall migration studies using fat simulating solvent heptane indicates that the migration values from different films and laminates are below the maximum specified limits by code of Federal Regulations (USA) for the intended use of packaging of oils and fats.

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Packaging and Storage Studies of Desiccated Coconut in Flexible Packages

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ABSTRACT

Desiccated coconut and coconut oil are the primary products of coconut which are of commercial importance. Desiccated coconut is dried, shredded white meat of processed coconut which is produced in considerable quantities sufficient for consumption by bakery and confectionery industries. There is great potential for export in future years. The product is highly sensitive to vagaries of climate and is prone to rancidity, loss of crispness and browning. Sorption studies have revealed that 2.9% moisture equilibrating to 50% R.H. is critical with respect to loss of crispness. FFA value of 0.3% (as lauric acid) is found critical with respect to rancidity.

Packaging and storage studies have been carried out under different climatic conditions using flexible packaging materials. Considerable increase in FFA value and no significant change in PV was noticed during storage. Browning of product was considerable at 40°C storage. Vacuum or nitrogen packaging had no beneficial effect in increasing the shelf-life. For short term storage of about 60 days under 65% R.H. and 27°C consumer unit pack made of 200 gauge HDPE, 350 gauge LDPE, 200 gauge PP were suitable. On the other hand, inclusion of MSAQ cellophone inside polyolefin pouches offered a shelf-life of 100 days. In moisture proof metallised polyester/poly or foil laminate pouches, shelf-life of more than 120 days was observed. For long term storage, especially for export, these laminates will offer desired protection against loss of crispness and rancidity.

The annual world production of desiccated coconut has been estimated at 1,30,000 metric tonnes[1]. India produces only a small quantity of desiccated coconut for internal consumption by bakery and confectionery industries.

Good desiccated coconut is snow white in colour, crisp and has the flavour of fresh coconut. This finds extensive use in the manufacture of sweets, cake dressings, pastries, chocolate and biscuit industry. It can also be used in curries and puddings in place of fresh coconut or copra. The product is highly sensitive to climatic changes and needs adequate protective package for desired shelf life. Desiccated coconut just like other oil containing materials is prone to rancidity, loss of crispness and browning during storage.

In commercial practice desiccated coconut is generally bulk packed in 25 kgs units in plywood chests lined with grease proof paper or polyethylene. Consumer packs of 1 Kg. or $\frac{1}{2}$ kg. generally comprise a double pouch with an inner grease proof paper and an outer 150-200 gauge LDPE. In order to design a suitable functional package physico-chemical changes of the product under varying humidity conditions packaging and storage studies under different conditions of storage in consumer unit pouches made of various flexible packaging materials were carried out.

Materials and Methods:

Product: Freshly prepared desiccated coconut procured from a local food industry was used in the investigation.

Chemical analysis: The fat content of the product was estimated by AOOC method[2]. The product had a fat content of about 70%.

Peroxide value (PV) and free fatty acid (PFA) value were determined periodically using standard methods[3, 4].

Moisture content of the product was determined by ISI method[4].

Sorption Studies: To study the influence of moisture on the keeping quality of the product, the humidity moisture relationship of the product was studied at 27°C by exposing weighed quantities of sample to different relative humidities ranging from 11 to 92% built in desiccators using appropriate saturated salt solutions[5]. The samples were periodically weighed till they attained practically constant weight or showed the signs of mould growth whichever was earlier. In order to study the effect of moisture on rancidity about 100 gm of the sample was exposed to different humidities and analysed for PV and FFA at the end of 70 and 105 days. The results are presented in Table 1.

Packaging materials: Considering the economics and physico-chemical attributes of the packaging materials and also the product deterioration characteristics pouches (210×150 mm) made of the following materials were selected for storage studies. Included in brackets are the water vapour transmission rate expressed as gm/M^2/day under 90% RH gradient at 38°C.

(1) 350 gauge low density polyethylene LDPE (3.6)

(2) 200 gauge high density polyethyle HDPE (3.2)

(3) 200 gauge polypropylene (PP) (4.1)

(4) Double pouch of MSAQ cellophane (60) inside and 350 gauge LDPE or 200 gauge HDPE or 200 gauge PP outside.

(5) Saran coated cello/poly (6.4)

(6) Metallised polyester/poly (0.8) (air or vacuum or nitrogen packed)

(7) Paper/0.009 mm foil/polyethylene (Nil) (air or vacuum packed)

Storage Studies: The pouches were filled each with 250 gm of the sample, heat sealed and stored at 38°C and 90±2% RH, 27°C and 65±2% RH, or exposed to ultra violet light at ambient condition (temp. 26-32°C, 40-70% RH) for one hour a day.

For vacuum packs, the product was sealed to less than 1" Air pressure inside and for nitrogen pack, the pouch was evacuated to less than 1" metric unit Air pressure flushed with nitrogen and sealed. The samples withdrawn periodically were analysed and overall acceptability was evaluated by a panel of ten judges for changes like loss of crispness, colour change and rancidity. The results of the above studies are presented in Table 2.

Results and Discussions

Sorption Studies: Desiccated coconut with an initial moisture content of 1.5% (dry) and fat content

Table 1. Moisture relationship of desiccated coconut at 27°C and changes in PV and FFA under varying condition of humidity

No.	% RH	% EMC on dry wt. basis	Acceptability score w.r.t. loss of crispness. Max. score 10	Exposure for 70 days			Exposure for 105 days		
				PV	FFA	Acceptability w.r.t. rancidity	PV	FFA	Acceptability w.r.t. rancidity
1.	11	1.2	9.2	1.7	0.20	Not rancid	3.7	0.41	Highly rancid
2.	22	1.5	8.8	1.4	0.22	Not rancid	2.2	0.45	"
3.	32	1.9	8.4	2.1	0.22	Not rancid	3.0	0.65	"
4.	44	2.4	6.0	2.8	0.29	Not rancid	2.9	0.74	"
5.	56	3.3	6.0	2.7	0.30	Not rancid	2.8	0.76	"
6.	64	3.7	4.4	2.8	0.34	Rancid	2.8	0.79	"
7.	75	5.8	3.2						
8.	86	9.5	Mould growth after 20 days						
9.	92	13.3	Mould growth after 15 days						
	IMC	1.5%							
	ERH	20%							
	CMC	3%							
	CRH	50%							

Table 2. Physico-Chemical changes and Shelf-Life of Desiccated Coconut during storage under different conditions in Flexible Packages

No.	Packaging materials	92% RH and 38°C					65% RH and 27°C					UV exposure				
		Storage period in days	%MC	PV	FFA	Shelf life	Storage period in days	%MC	PV	FFA	Shelf life	Storage period in days	%MC	PV	FFA	Shelf life
1.	350 gauge LDPE	30×	4.4*	0.7	0.21	9*	40	2.2	2.1	0.21	65**	30	2.1	1.4	0.18	64*
		60×	5.1*	2.0	0.33**		80	2.9	2.2	0.37**		60	2.9	1.5	0.26	
		85×	5.3*	1.3	0.44**		120×	2.7	0.7	0.28	120**	85×	2.1	0.7	0.25	95**
2.	200 gauge HDPE	30×	3.7*	1.4	0.21		40	2.0	1.4	0.22	73**	30	2.2	2.0	0.17	70*
		60×	3.9*	2.9	0.27	15*	80	2.5	1.4	0.32**		60	2.7	2.0	0.27	
		85×	4.4*	1.4	0.44**		120×	2.3	0.7	0.25	120**	85×	2.0	0.7	0.24	98**
3.	200 gauge PP	30×	4.8*	1.5	0.29		40	2.4	2.1	0.23	71**	30	2.3	1.2	0.16	64*
		60×	6.5*	3.6	0.39**	7*	80	3.1*	1.4	0.32**		60	2.7	2.2	0.27*	
		85×	6.9*	2.0	0.52**		120×	3.0*	1.4	0.25	120***	85	2.3	0.7	0.28	90**
4.	MXXT Cello/poly	30	6.9*	2.1	0.39**		40	2.6	2.9	0.25		30	2.6	1.8	0.18	
		60	9.6*	3.7	1.45**	4*	80	3.1*	1.4	0.37**	58**	60	3.1*	3.1	0.22	53*
		85	—	—	—	—	120	—	—	—	—	85	3.0	0.7	0.42	
5.	Metallised polyester/ poly (Air)	30	2.7	1.1	0.25		40	2	1.4	0.18						
		60	3.4*	2.4	0.35**	37*	80	1.9	1.4	0.19	>180					
		85	4.4*	1.5	0.40**		120	2.1	—	0.21						
6.	Metallised polyester/ poly (Vacuum)	30	3.3*	1.3	0.27		40	1.9	1.4	0.21						
		60	4.1*	2.8	0.3**	17	80	2	1.4	0.19	>180					
		85	6.1*	1.4	0.47**		120	2.5	—	0.21						
7.	Metallised polyester/ poly (Nitrogen)	30	2.8	1.3	0.23		40	1.9	1.4	0.21						
		60	3.7*	2.7	0.32**	37*	80	2.0	1.4	0.19	>180					
		85	4.3	0.7	0.45**		120	2.2	—	0.21						
8.	Paper/foil/poly. (Air)	30	1.6	0.6	0.13		40	1.7	1.6	0.20						
		60	1.7	1.7	0.19	80**	80	1.7	1.4	0.14	>180					
		85	1.6	0.7	0.29		120	1.8	—	0.22						
9.	Paper/foil/poly (Nitrogen)	30	2.1	0.8	0.14		40	1.7	1.4	0.15						
		60	2.3	1.5	0.18	80**	80	2.0	1.4	0.17	>180					
		85	1.6	0.7	0.3**		120	1.8		0.22						

×—MSAQ cellophane pouch was inside the polyolefin pouches

*—Not acceptable with respect to crispness

**—Not acceptable with respect to rancidity

of 70% equilibrated to an RH of 20% (Table 1). Low equilibrium moisture content (EML), value even under high humidities and also typical sigmoidal type sorption isotherm suggests that the sorption characteristics is typical of a high fatty food. The product having EMC of 9.5% and 13.3% at 86% RH and 92% RH developed mould growth within 15 and 20 days respectively. The product equilibrated to 11, 22 and 32% RH had an EMC of 1.2%, 1.5% and 1.9% respectively and was crisp and had an acceptability score of 9.2, 8.8 and 8.4 out of 10. At 44% and 56% RH, the equilibrated product had an EMC of 2.4 and 3.3% respectively. These two equilibrated samples were acceptable with an acceptability score of 6. However, the product with an EMC of 3.7% equilibrating to 64% RH was slightly soggy and with EMC of 5.8% equilibrating to 75% RH, was very soggy and unacceptable. Based on the acceptability and sigmoid type sorption isotherm which shows steep raise above 50% RH, EMC of 2.9% corresponding an 50% RH is considered critical with respect to crispness of the product. ISI[4] specified 3% moisture content as maximum for desiccated coconut which is same as the one observed from sorption data.

The FFA value of equilibrated samples (Table 1) increased with RH. The sample stored at 44% RH with a FFA value of 0.29% was acceptable at the end of 70 days, where one equilibrated to 56% RH had an FFA value of 0.3% showed a slight off flavour and was just acceptable. Hence an FFA value of 0.3% can be considered to be critical limit of acceptability. This also corresponds to the maximum limit of 0.3% specified by ISI[4]. After exposing for 105 days, FFA value in the equilibrated samples increased with moisture content of the product and crossed the limit of 0.3% in all cases and the samples were highly rancid. However, there was no appreciable change in PV in the samples equilibrated to different humidities.

Packaging

92% RH & 38°C (Accelerated Condition): The actual shelf life of the product in different packaging materials, calculated graphically (with critical limits of 3% moisture and 0.3% FFA) is also presented in Table 2. From this it can be seen that the product has less than 15 days shelf life in polyolefin pouches. Metallised polyester/poly packs will offer a shelf life of 35 days and for longer shelf life under this condition foil laminate is the best choice. In all the packaging materials slight browning was also observed at the end of terminal storage life.

65% RH and 27°C (Is standard condition): The product packed in cello/poly and polyolefin pouches was not acceptable at the end of 80 day sstorage (Table 2). Here rancidity appears to be more predominant than loss of crispness. In 350 gauge LDPE pouch considerable seepage of fat was observed at the end of 40 days storage, which is undesirable as it can smudge the printing on pouches. On the other hand it is observed that introduction of MSAQ inner pouch along with polyolifin helps in increasing the shelf life which also helps in preventing the seepage of fat. The product packed in double pouch reached critical value of moisture and also critical FFA level at the end of 120 days storage and was just acceptable. The product packed in metallised polyester/poly and foil laminate pouch was good and acceptable at the end of 120 days of storage. In these two highly moisture proof packages, the trend in results suggests a storage life of more than 180 days. Browning of the product was not noticed in this condition of storage.

Storage at room condition of 40-70% RH & 26 to 37°C and U.V exposure for 1 hour daily:

As can be seen from Table 2 the shelf life of the product is about 60 days in polyolefins which is similar to storage life at 65% RH and 27°C. In cello/poly pouches also the CMC of 3% was reached within 60 days. The improvement in the shelf life by introduction of MSAQ cellophane inner pouch was not as much as in 65% RH and 27°C and the shelf life in double pouch was about 85 days. U.V light exposure is found to have practically no effect on the development of rancidity as it is hydrolytic rancidity which is responsible for deterioration of the product. The product packed in different flexibles was not acceptable at the end of 110 days due to development of rancid odour.

Conclusion

Humidity-moisture relationship studies at 27°C has revealed that a moisture content of 3% (dwb) equilibrating to 50% RH is critical with respect to the crispness of the product as above this level, the product becomes soft and soggy loosing crispness.

From chemical analysis of the sample equilibrated to different relative humidities, a FFA value of 0.3% (as lauric acid) is found to be critical with respect to acceptability of the product.

It is observed that measurement of FFA value i. e, hydrolytic rancidity is a better index of measuring

the deterioration of the product during storage rather than peroxide value which is a measure of oxidative rancidity. This explains why vacuum or nitrogen packaging had no beneficial effect in increasing the shelf life.

Packaging and storage studies of the product in different flexible pouches under different storage conditions has revealed that under normal storage condition, the product can have a storage life of 60 days in polyolefin pouches with respect to both loss of crispness and development of rancidity. On the other hand, the shelf life of the product can be more than 180 days in highly moisture proof metallised polyester/poly or foil laminate pouches A double pouch of MSAQ cellophane inside and polyolefin outside will offer a shelf life of 120 days and prevents seepage of fat, which was considerable in polyethylene pouches. Thus the results suggests that for long term storage and also for export trade, highly moisture proof barrier material are most suited in offering the desired protection against ingress of moisture and also development of hydrolytic rancidity which actually increases with increase in moisture and temperature.

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Polyethylene Bag Packing for Carbonated Curd

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ABSTRACT

Storage studies have been carried out on carbonated curd packed in sterile polyethylene bags and stored at room temperature (25° to 37°C). The curd was produced by using pure cultures of lactic acid bacteria. Curd could be stored safely at room temperature for one month in 500 gauge polyethylene bags without any spoilage due to growth of yeast, mold or spore bearing bacteria and without development of foul smell.

Introduction

Curd is a fermented milk product used by the majority of the population in India as an article of diet. It is prepared indigeneously by using naturally available mixed culture. The method of production and selling is not hygienic and, therefore, shelf life of the curd is very low since the culture used is contaminated with yeast and mold. Therefore, curd as an industry is not flourishing in India due to its low shelf life.

In the past, few attempts were made for production and packing of fermented milk products in hygienic condition with improved keeping quality with plastic containers as packages. (Hansen, 1973; Fwickiger, 1975; Aleksieva, 1977).

In the present investigation attempts have been made to increase the shelf life of curd at room temperature by carbonation at 13.8 Kpa and using pure culture and packing in sterile polyethylene container.

Material and Methods

Milk: Milk was heated at 95°C for 10 minutes in a glass flask with a cotton plug.

Culture: The starter culture used in the investigation was *(a)* Culture 'A'—*S. lactis*+*S. diacetilactis* (1:1) *(b)* Culture 'B'—*S. thermophilus*+*L. bulgaricus* (1:1)

Inoculum: Fresh growing above mentioned cultures were used as inoculum to the extent of 0.2 per cent.

Polyethylene bags: *Polyethylene* roll of about 5 inch (width) and 500 gauge was obtained directly from the manufacturing factory and was found sterile inside.

Heat treated milk was inoculated with the cultures and carbonated at 13.8 kpa for 2 minutes and was transferred aseptically into the bags of about 500 ml capacity each and the bags were sealed and incubated at 37°C for 12 to 16 hours. After setting of the curd the bags were stored at room temperature. Observations on acid development were recorded by following standard I.S.I. procedure. The curd was judged by following the score card method developed by Nelson and Traut (1964), Curd was examined microscopically following standard simple staining procedure. In all, six trials were conducted and results presented are the averages of six trials.

Results and Discussion

It is seen from the Table 1 that the acidity developed during one month storage period was not more than 0.92 per cent in sweet curd with culture 'A' and 1.85 per cent in sour curd with culture 'B'.

It can also be noted from the same table that the curd samples when subjected to judging, scored more than 90 marks and were found in good condition during the storage period of one month. Microscopic examination revealed that no organisms other than those used as culture organisms were visible under microscope which means that the curd was not bad from the health point of view during storage and could be used for human consumption.

Table 1. Observations on quality of carbonated curd packed in polyethylene bags

Days of storage	Sweet curd, Culture 'A', *S. lactis*+*S. diacetilactis*							Sour curd, Culture 'B' *S. thermoophilus*+*L. bulgaricus*						
	Acidity (%)	Total score	*Microscopic observations*					Acidity (%)	Total score	*Miscroscopic observations*				
			Cocci	Bacilli	Yeast	Mold	Spore			Cocci	Bacilli	Yeast	Mold	Spore
1	0.62	99	+	—	—	—	—	1.10	99	+	+	—	—	—
3	0.63	98	+	—	—	—	—	1.10	98	+	+	—	—	—
5	0.64	97	+	—	—	—	—	1.20	97	+	+	—	—	—
7	0.66	96	+	—	—	—	—	1.30	96	+	+	—	—	—
9	0.67	95	+	—	—	—	—	1.45	97	+	+	—	—	—
11	0.71	94	+	—	—	—	—	1.50	94	+	+	—	—	—
13	0.74	93	+	—	—	—	—	1.60	93	+	+	—	—	—
15	0.76	92	+	—	—	—	—	1.66	92	+	+	—	—	—
17	0.78	91	+	—	—	—	—	1.67	91	+	+	—	—	—
19	0.80	91	+	—	—	—	—	1.70	90	+	+	—	—	—
21	0.82	91	+	—	—	—	—	1.72	90	+	+	—	—	—
23	0.84	90	+	—	—	—	—	1.80	90	+	+	—	—	—
25	0.88	90	+	—	—	—	—	1.84	90	+	+	—	—	—
27	0.90	90	+	—	—	—	—	1.85	90	+	+	—	—	—
29	0.92	90	+	—	—	—	—	1.85	90	+	+	—	—	—

Note: + =Present; — =Absent.

Finally it could be concluded that curd prepared by using pure cultures and carbonated at 13.8 kpa could be packed in sterile polyethylene bags and stored safely for one month without any spoilage, at normal room temperature.

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Packaging Performance Assessment In Beverages By Sensory Analysis

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ABSTRACT

The performance of a package and the food packed in it is closely related to its acceptance by the consumer. The acceptance decision depends on the food/beverage tasting 'just right' and in turn on the sensory attributes of the food at the time of use, in addition to its integrity and appearance in packed form.

An attempt has been made to identify and quantify changes in sensory quality of orange squash as an example. Recognition threshold test has been used to relatively quantify the intensity of aroma. Adaptation of dilution method to obtain Relative Quality Index has been discussed. The findings from these tests have also been supplemented by use-level studies. These three tests in combination provide sufficient information for open dating. The method with modifications can be used in testing packaging performance in other situations or foods.

Introduction

Packaging of food/drink forms an integral part in the food chain of production through consumption. The package is expected to assure safety and quality of the material it contains. Glass and tin containers are the conventional packaging materials used for food. Even beween these, glass is by far the best and tin comes next as it may leave a metallic note depending on the quality of metal used and the nature of food packed.

Recently use of non-conventional packaging materials by many food producers is increasing as they offer some advantages during packing and transportation. However, the performance *per se* of these packaging materials is important and will have to be assesed for assuring safety and quality during their continued use. The various parameters for assuring the performance and the storage behaviour of the packaging material include the physical, chemical, microbiological and sensory parameters during storage. Of these the sensory parameters are important from the point of view of the consumer who is the last link in the chain[1]. While most of the sensory attributes viz., colour, appearance and integrity are obvious and normally taken care of, the maintenance of appropriate and optimum flavour, particularly the absence of off-flavour and modification of initial flavour, which are the most important factors in decision making, are not sufficiently studied. The quantification of these quality attributes are important for decision making as regards open-dating of foods and beverages, and instrumental analysis for this purpose are attempted recently. Instrumental parameters either individually or in combinations, as Gas Chromatography for aroma or Ultrasonics for texture[2] reflect part of the behaviour of food. They do not reflect the sensory quality unless the predictive validations are available for interpretation.

Hence it is essential to have the changes in sensory quality of any product studied during storage, by using objective methods of sensory analysis. This will be very useful to the producers in the long run.

To highlight the above hypothesis, a case-study has been reported here on orange squash stored in glass and polyethylene bottles under different time-temperature schedules of storage. Several of the codified methods of sensory evaluation have been used to analyse fruit juice for quality. The methods have ranged from paired comparison as in looking for aroma loss or degradation by different methods of concentration[3], multiple testing for odor characterisation and ranking for nearness to original to relate the gas chromatographically identified

compounds[4]. Profiling for flavor has also been frequently used in fruits and juices. Threshold test has very frequently been adopted in specific area of isolation and characterisation of aroma impact components in fruits[5].

The threshold test has been first used in food commodities like coffee, spices, etc., by Tilgner[6]. A method for quality evaluation of orange squash/ juice is adopted here following threshold technique which can give the indication of aroma quality, and is directly related to possible consumer reaction.

Materials and Methods

Orange squash was stored at three temperatures: 1.67°C, ambient (27°-28°C) and 37°C in glass and High Density Polyethylene (HDPE) bottles upto six months. Periodically, they were withdrawn for sensory evaluations.

Sensory evaluation methodology and design:

Sensory evaluation studies were carried out to test for reduction or loss of orange aroma, pick up of plastic or other off-aroma, visual color change and indication of the shelf-life of the product when stored in glass or HDPE containers.

Three tests were used in the study with specific purposes.

(i) Threshold tests for orange aroma were used to quantify aroma loss with a trained panel and pick-up of plastic or other off-aroma was also checked. Tests were carried out with the ascending concentration series method. The increment of difference in concentration was decided by prior experimentation to ensure that the difference was not very wide, maintaining a geometric progression.

(ii) 'Relative Quality Index' was used as a 'possible method to follow aroma change with a semi-trained panel. Test samples were diluted at fixed concentration above threshold, where aroma was clearly perceived but color would not interfere. This same level was tested throughout the whole study, paired against a 'blank' for aroma difference identification and description.

(iii) Ranking test at use level as 'Ready-to-serve' was used with a semi-trained panel for testing the attributes of color, aroma, and overall quality. An incomplete block design was adopted to compare all the six samples along with a control sample. Ten replicates were recorded for each block. The same samples as in the incomplete block were used in 'Relative Quality Index' testing of the respective block.

Development of score card

For threshold tests, the normal threshold score card of INDIAN STANDARDS (IS 6273 Part II) with testing of serial dilutions was used with specific task to look for orange aroma.

In relative Quality Index and Ranking tests, the same samples were to be analysed in a block by each panelist, hence, the two tests were combined. The score card was designed first to analyse the paired difference test for dilution index followed by ranking for individual attributes at use level. Annexure 1 gives the score card used.

ANNEXURE—1

Score Card No...... **Product**.....

Name..... **Date**.....

Paired Comparison and Ranking

I. Paired Comparison

Samples are given in pairs

Taste the samples and judge whether they are same or different in **AROMA**

Indicate the nature of difference.

Pairs	I	II	III	IV
Code Nos.				
Same/different				
Nature of difference				

II. Ranking

Rank the samples for the attributes given.

The samples with the best attribute gets the I rank, the next best the II, and so on.

Please indicate your reasons for the ranking.

Ranks	I	II	III	IV	V
Colour					
Aroma					
Overall quality					

Comments, if any.

Signature

Sample preparation and presentation

For threshold tests, samples were diluted with water and covered a range from 1:1000 to 1:200. For 'Relative Quality Index" by paired test, the dilution of 1:500, selected by preliminary experimentation, was used throughout. They were tested paired against a blank (water) with care taken to randomise the first sample. Three pairs were tested in one session. In use-level testing, the recommended dilution of 1:3 was used. The samples were presented in sets of four. 20-24 panelists participated in the tests.

Samples were tested at room temperature.

Analysis of data

Threshold of orange aroma was represented as arithmetic mean of the dilution factor.

Relative Quality Index test was first analysed for significance of difference identification in the pairs by binomial distribution followed by frequency of use of descriptors of difference.

Ranking tests were analysed for overall significance either by Durbin's test (Durbin, 1951) when an incomplete block design was used or by Kramer's rank sum method (Kramer and Twigg 1970) when all the samples were ranked by each panelist. The formation of homogeneous groups of samples was achieved by confidence intervals for rank sums based on normal approximation.

Results and Discussion

Orange aroma was found to be mostly due to the orange oil which forms about 1% by weight of the fruit. The aroma component of the liquid phase in orange juice was equally important. In the studies of changes in orange juice on processing, the development of tallowy, cardboardy or castorlike aroma in stored orange juice is known to occur due to hydration-dehydration reaction of d-limonene (ACHD-reaction). Also linear increase in carbonyls is recorded early, but the sensory changes are noticed only later[7]. This could be due to the fact that the sensory evaluation would have been done in orange juice at use level and not at threshold of aroma. Though the possibility of testing of beverages by dilution was known, the technique was not extended to detect defects/differences quantitatively at threshold levels. In studies where possible flavor changes in orange juice was to be detected due to addition of protein from cheese, whey, soya and protein hydrolysates and viciafaba hydrolysates also, difference tests were used at arbitrarily selected levels of incorporation and not the more informative threshold tests;. But in the present study where threshold test for recognition threshold of orange aroma was used, the loss of volatiles was very distinctly noticeable. The thresholds for orange aroma were the highest in HDPE stored samples followed by glass stored samples at higher temperatures and the cold stored control had the lowest threshold. Retention of this intensity of orange aroma in control sample was seen till 100 days (Fig. 1) in the study.

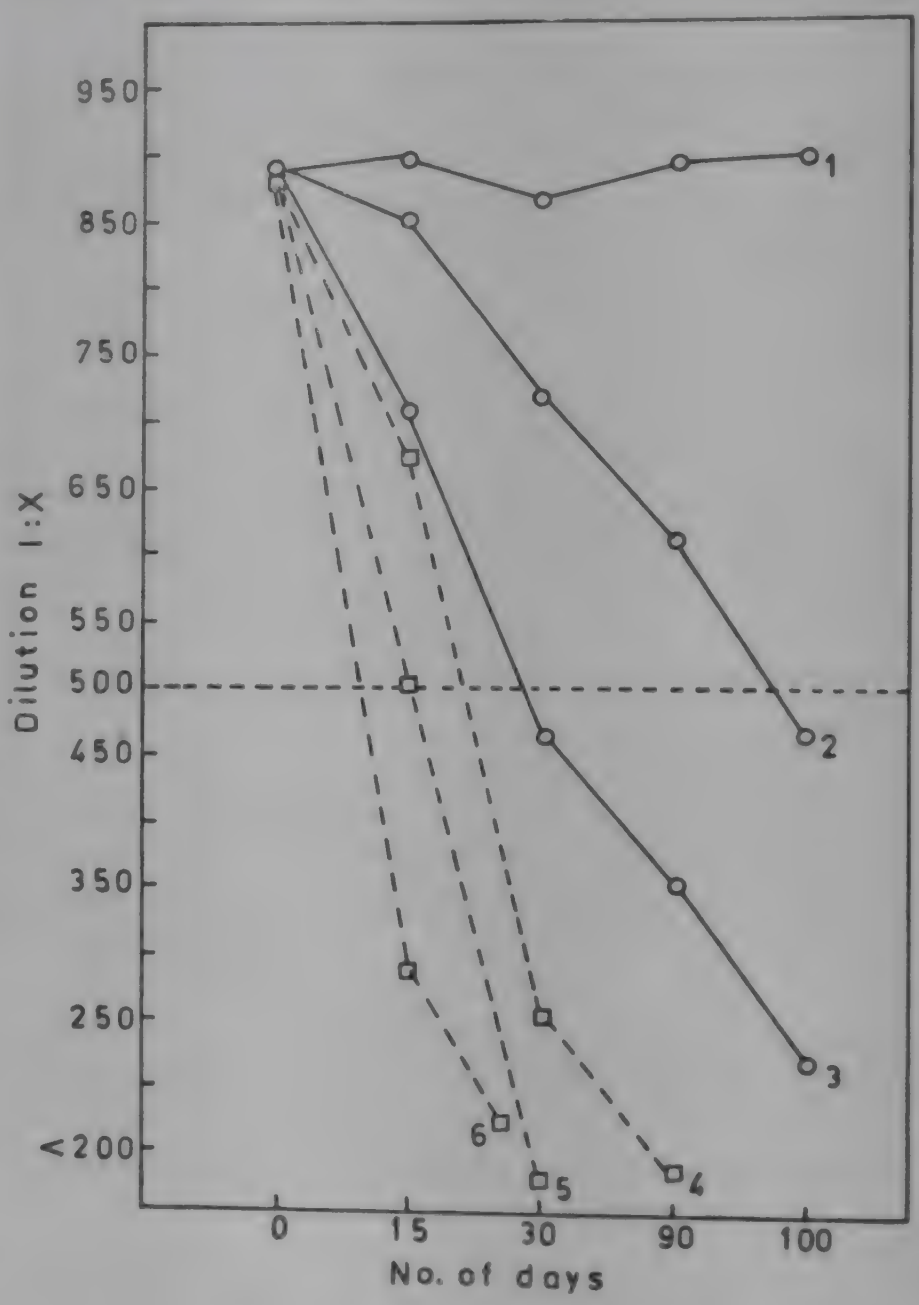

Fig. 1. Aroma threshold in orange squash

(1) Glass, 1.67°C,
(2) Glass, Ambient temperature
(3) Glass 37°C
(4) HDPE 1.67°C,
(5) HDPE Ambient temperature
(6) HDPE 37°C

Note: Medical cut off line indicates poor overall quality as judged by use-level ranking.

The use of threshold test results is two fold, *(a)* the quantitative loss of orange aroma that is perceived sensorily is of use in extrapolating for package material or time-temperature schedule of storage in R & D work, (*b*) the relation of dilution at threshold to overall quality at use level can give a quick valuation of product when reaching a consumer. Figure 1 shows the findings of threshold test recorded as the mean value of threshold. The cut-off line medially indicates the judgement at use level by Ranking test upto which the loss of aroma was not noticed by the semi-trained panel. Only when the loss exceeded this level, it was reflected in poor quality ranking of samples.

The Relative Quality Index is one of the adoptations of threshold method. The fixed level (1:500 ml) was used to compare loss of orange aroma and the findings were similar to threshold tests in indicating the lowering of intensity of orange aroma in the same order.

The consumer reaction acceptance being the ultimate goal, testing at use level is important. Since this study involving time, temperature, and packaging effects required preference ranking for six samples along with paired tests in one sitting, an incomplete block design was made use of. The sensory quality attribute of color (Figure 2A) showed a significant change in 37°C and ambient temperature in HDPE stored samples by 15 days itself as compared to glass stored samples. No difference was noticed among cold stored (1.67°C) samples, even by end of the study. Cold stored samples in both HDPE and glass were superior to higher temperature stored samples upto 90 days. At 180 days, 37°C, HDPE stored samples was found unfit for evaluation. Among the the rest, ambient and 37°C glass stored sample was inferior to HDPE stored samples due to bleaching of color. Cold stored samples in both the packagings were found to be equally good.

The changes in aroma (Figure 2B) were least in

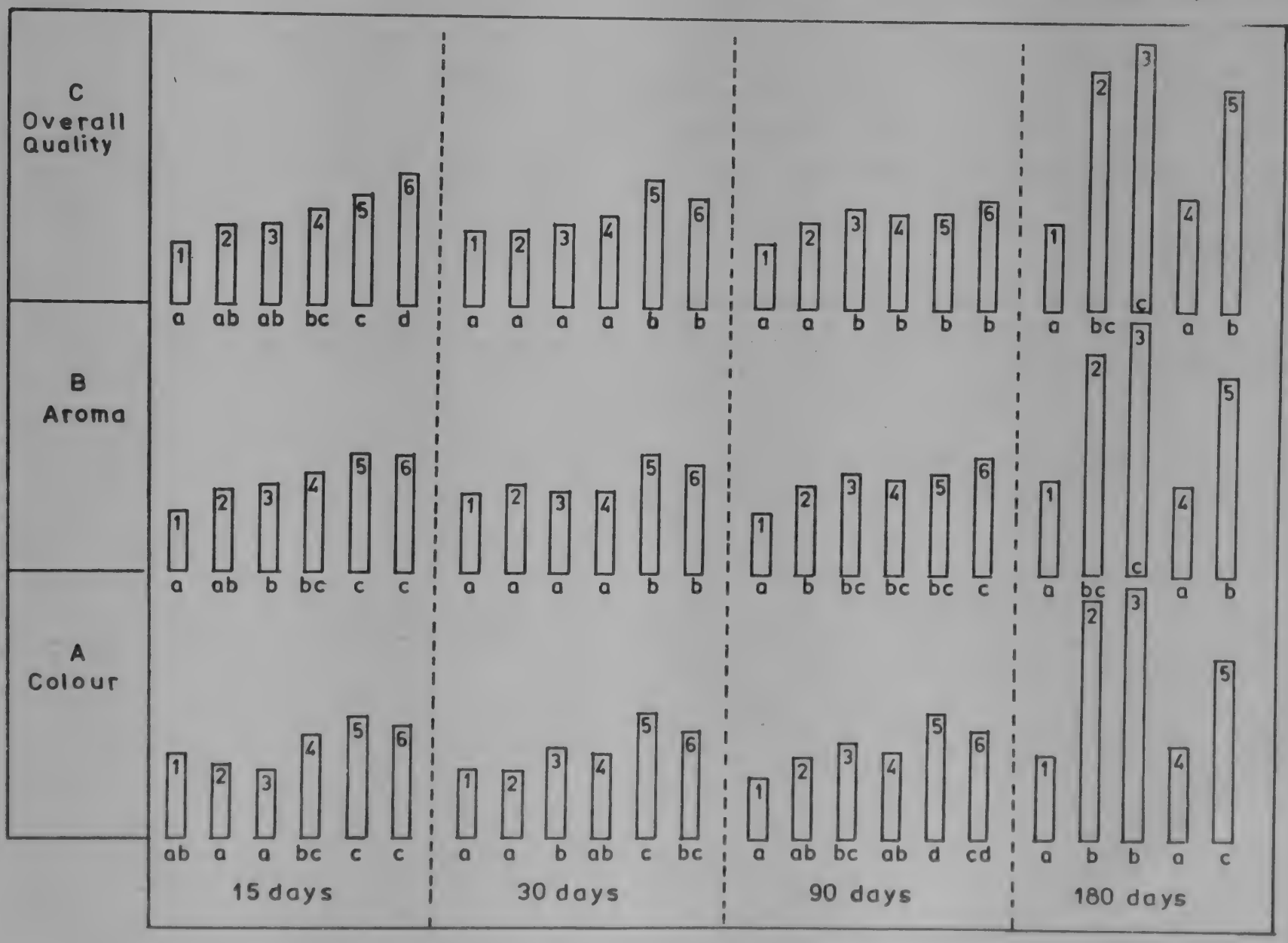

Fig. 2. Rank sums of orange squash in use level.

(1) Glass, 1.67°C (2) Glass, ambient temperature (3) Glass 37°C (4) HDPE, 1.67°C
(5) HDPE, Ambient temperature (6) HDPE 37°C

Note: Samples carrying the same letter are not significantly different.

the cold glass stored samples throughout the study. Under the same conditions, HDPE stored samples retained the aroma only upto 30 days. This loss in HDPE stored samples was very pronounced at ambient and 37°C. Also, a pick up of off-aroma was noticed by 180 days in HDPE stored samples. The pattern of aroma change was similar to the findings from aroma threshold tests (Figure 1).

Figure 2C represents the overall quality of the orange squash. This can be seen to closely reflect the trend noticed in aroma changes. Glass stored samples at lower temperature was superior to others. The loss of aroma in HDPE due to permeability resulted in lower overall quality ranking, though no significant color change was seen. The overall quality judgement is therefore more influenced by variations/ loss in aroma than by color difference.

Hence, it can be concluded that effective quantification of change/loss of aroma in a beverage can be clearly assessed by a trained panel using recognition threshold for aroma. Alternately, the 'relative quality index' by the semi-trained panel also gives an indication of the quality change much earlier than at use levels, which will assure the consumer acceptance and in turn reflect packaging performance.

Acknowledgement

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Package Performance

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ABSTRACT

The performance of the packages for food has to be viewed as a total system encompassing preservation, protection, handling during storage and transport, and all this needs to be achieved at minimum overall cost. The package performance in relation to product characteristics and also packaging material characteristics are dealt in the paper.

Man has had to conserve and preserve his food so that an abundance obtained at harvest or following a successful hunt can be stored for use at a later date as a protection against famine, until further supplies are obtained. Few people would question the importance of good food, in adequate quantities, for the preservation of health. Changing social and work pattern in recent times have encouraged the growth and development of "Convenience foods", with ramification for the packaging industry as well. While packaging is required to fulfil a number of different functions, its primary roll is to retard or prevent loss of quality, both nutritional and aesthetic and to give protection against environmental contamination.

The food products can be broadly classified into two groups viz. fresh and processed. Fresh food consists of fruits and vegetables, pulses, cereals, grains etc. while confectioneries, snack foods etc. form the processed foods.

The processed food can be in a ready to eat form like snack food, wafers, biscuits, etc. while some need to be cooked to be brought to a stage when it is made palatable like dehydrated food or products preserved in brine, in oil etc.

While the consideration for the fresh food products would be for protection against mechanical hazards like impact, puncture etc. the requirements for the processed foods would be more on preservation aspects. Thus the requirements vary with regard to the type of the product.

In a dynamic situation as the requirements of a package keep changing with the evolution of newer materials, techniques, transportation the performance parameters also keep varying. Mainly the package performance can be attributed to the three areas.

1. preservation of the food product till it is consumed.
2. protection of the food product
3. packaging as a contributory factor in the total distribution system.

As the products have to be distributed, which involves handling, storage, transport etc., the package, further to rendering protection and preservation characteristics should also be enable to afford ease in distribution. Thus the performance of a package has to be viewed as a total system encompassing preservation, protection, handling, storage, transport etc.

In the light of this concept one can analyse the performance of the package.

The principal requirements of a food packaging material can be classified as follows:

1. Transparancy of surface gloss for customer appeal.
2. Control over transfer of moisture.
3. Control over transfer of other gases/vapours.
4. Absence of toxic constituents.
5. Low cost.

Control over changes in the moisture content of a food during storage is most important. Some products viz. snack foods and biscuits must be

packed in a material with a very low permeability to water vapour to preserve crispness. It is also essential to reduce moisture losses with many products and again a low permeability film would be required. In other cases some loss of moisture is desirable to avoid sweating contamination on the inside of the package and concomitant loss of transperancy as well as increased risk of mould growth.

In addition to transfer of water vapour in and out of the packaging material control over permeability to other gases such as oxygen and carbon-dioxide is also very important.

Most fresh foods need to breathe. Hence the packaging material used for these products must allow ingress of oxygen and respiration of carbon-di-oxide. Fresh meat also requires ingress of oxygen to maintain a satisfactory colour. On the other hand, foods with high fat content like dairy products, bacon, crisps etc. become rancid on exposure to oxygen and are often vacuum packed or packaged in an atmosphere using a material of very low permeability. Low permeability materials are also useful for the packaging of fish or coffee where the odour must be contained strictly within the package.

The package must also protect the product from hazards like impact, puncture etc.

The broad range of activities concerned with efficient movement of finished products from the end of the production to the consumers can be defined as physical distribution of the product.

We have three stages in physical distribution:

1. Storage
2. Handling
3. Transport

The Package has to stand the varying conditions of storage from high temperature, high humidity to low temperature/low humidity. During handling, the package is subjected to various stress/strain in relation to its gross weight and the handling equipment employed.

In the movement of the goods the package is subjected to various hazards depending upon the mode of transport used.

The handling and transport damage can be reduced if modular system of freight is adopted.

Performance and cost:

The various costs included in packaging are: Packaging development cost, Quality control cost, Inplant movement cost, Cost of packaging material, Packing cost, Storage and filled packaging cost, Transport cost, Insurance cost, which are tangible.

The performance of the packaging therefore will be in relation to the protection, preservation requirements of the product with reference to its storage and the mode of transportation employed and all this is to be achieved in the minimum overall cost.

Aseptic packaging — A New System for the integrity in Bag-In-Box packaging

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The growth of Bag-in-box packaging of liquids has been one of the most spectacular packaging developments of the past two decades, and nowhere has it been more spectacular than in Australia where it revolutionised the wine industry.

In the early 1970's wine consumption in Australia stood at a little less than 7 litres per head per annum. Today, the figure is 20 litres per head per annum with almost 60% of total wine sales now packaged in this form.

Initially, through development of a suitable laminate structure based on a coated nylon film substrate and L.L.D.P.E. as the sealing web the system was developed.

Since then, many other liquids (Milk, Fruit Juices, Cider, Vinegar, Cooking Oil etc) have found their way into Bag-in-Box using an enormous variety of taps, plugs and closures. However, with few exceptions, all these systems have sufferred from a common fault—poor shelf life, because of the problems associated with oxygen ingress. We knew that about 90% of the oxygen problems emanated from the gland/tap area and we recognised that if these fitments could be isolated from the product by some means, the oxygen permeation would be significantly reduced.

Hence, it was thought to evolve a system which would ensure that the product shelf-life would be increased greatly, whilst at the same time, ensuring that the filling operation was not affected in any way.

A list of all the parameters considered to be essential to such a system was drawn up, and a study group appointed to work on a feasibility study.

It was found that as the weak spot in the bag was the gland (remembering that about 90% of all oxygen ingress occurred through the gland area), that we should simply put a patch of material with at least the same barrier properties of the material from which the bag was made, over the gland hole cut-out, and heat seal it inside the bag after the product has been filled into the bag. It sounds very difficult, but in practice, it has not proven too hard to do.

Firstly, the gland size (remember, we were at this time aiming the result at the wine market) was reduced, and to the back of the polythene gland, a circular piece of the bag material by heat sealing it in three places was fixed. The gland with the membrane attached was then heat sealed into the bag in the normal way. When the gland was offered to the filling head, we found that the product flowed quite well past the membrane, which flexed sufficiently to allow free passage of the product.

At the end of the filling cycle, and while the gland is still attached to the filling head, a heat sealer operates from the back of the bag, sealing the membrane to the back of the gland. Because the ,'Back" web of the membrane material consists of a film which is incompatible to heat sealing to polythene the back layers of the bag do not attach to the membrane, even though they do heat seal to themselves. In this way, the hole cut into the bag, into which the gland is placed, is ",'patched" with material of similar barrier properties to the bag films and thus, the increased barriers to O_2 lengthen the shelf life of the product by as much as 75%.

This system became known as "Wrightseal".

This system found favour in several wineries in California and British Columbia and for hot filling fruit juice in Australia, U.K. and Africa, because the sealed membrane keeps the hot juice away from the tap, which would otherwise be badly effected by the heat, unless made from heat resistant polymers, in which case it simply becomes too expensive to use.

Whilst there were some more developments in the Bag-in-Box problems, the world was slowly but surely accepting the "Paper Bottle" on "Brik" as a packaging medium, and the rapid growth of

this aseptic packaging medium has had an interesting rub off into Bag-in-Box packaging.

About three years ago, it was found that consumers, in countries where hot filled or preservatised Bag-in-Box juice was on sale, were comparing its taste with "Brik" type aseptically packaged product and asking why the juice from the small packs tasted so much better than that from the larger Bag-in-Box packs.

A solution to this problem came up quickly which like most good ideas was quite simple. A new system of aseptic filling of Bag-in-Box was conceived—similar to the sterilization of a body area prior to an injection—and now we are able to offer it to the world, first to packers to enable them to achieve worthwhile savings in cost whilst at the same time presenting a better product to the consumer.

In New South Wales, the system was tested and approved for commercial release for high products, This was in Mid 1983, and the first installation was at Knispel Fruit Juices Pty. Ltd in South Australia. After four months of commercial trials and production the Intasept system for high acid products was released and we now have installations in the USA, U.K. and Africa.

Work continues on low acid products and the first installation for coconut milk and cream is in Singapore. Production trials to pack pasteurised milk on the intasept filler to increase the shelf life of fresh milk is planned this month. This is in addition to packing UHT milk.

Aseptic filling is simply providing a means of transferring commercially sterile product from a closed environment (in this case a sterile pipeline) into a sterile container, under sterile conditions and sealing that container to prevent the ingress of contaminants in subsequent handling.

1. With the new system, it is possible to achieve this by placing another membrane over the top of the gland of an otherwise standard wrightseal bag, fully sealing it and then subjecting it to Gamma Radiation to sterilize the bag. Despite subsequent handling in normal ambient conditions, the inside of the bag remains sterile.

2. The Aseptic transfer of product is achieved by offering the bag up to the filling head where the top membrane forms the "Floor" of a sterilizable chamber between the membrane and the actual fill value itself. This interspace is sterilized by steam which must be dry and filtered and needs to be at a surface temperature of 145°C (which means it needs to go into the port at 160°C).

3. A cutter integral with the fill valve then punctures the top membrane, the product proceeds via the now sterile pathway into the bag, a small burst of steam follows up the product to chase the remaining product into the bag and then the bag is sealed, as in normal systems.

The essential point is that at no time during the transfer process is the product pathway exposed to the external environment, the transfer is achieved in a closed system and the sterile container is heat sealed, providing a fully sealed unit to which a dispensing device can be added if desired.

The system has some very valid advantages over other competitive systems in particular:—

(1) Sterilization is by steam only, no hydrogen peroxide is used. To sterilize the top membrane, an area of 3 cubic centimetres is flushed by steam at 160°C for 3 seconds.

(2) No special factory environment is required. Other systems require a positive pressure chamber using sterile air.

(3) Pre-sterilization of line, equipment and fill valve components is very simple to carry out and is most positive.

(4) The Intasept filler can be portable and easily installed requiring only electric power, compressed air and steam.

(5) Energy requirements of the system are minimal.

(6) The Intasept membrane system is positive and proof against ingress of organism both prior to and post filling. Other systems rely on friction fit components.

(7) Filling can be interrupted at any time and resumed without delay, for re-sterilization, etc.

(8) Operator skill requirements are minimised.

(9) Capital investment is relatively low, provided upstream equipment is available.

(10) The system is very flexible. Up to 30 litres can be filled. To change the volume, flick volume switch on the counter.

(11) The full accuracy is plus or minus 0.25% to 0.5% depending on the product.

Services Required:

* Electricity supply	220-240/1/50 or as required
* Compressed Air	7 Bar, Regulator on the Filler, Dry Filtered
* Steam	Filtered at Min. 4 Bar supply, quality as for UHT pre-sterilization supply.

Aseptic Pouch Filler – Form, Fill and Seal Machine

M. PODSELVER

Samarpan Fabricators, Thana-400 004

Since 1962, PREPAC company has developed packaging systems for liquids. The First was for packing detergents and shampoos in PVC bags, these packages are very well known on the market in these years.

Then, it was thought that this kind of package could be used for liquid food, and especially for pasteurized milk. Of course, PVC could not be used, but polyethylene started to be available, was a light material (0.9 g/ml density) at an attractive price and could be used safely to pack food products.

So, we designed and manufactured a filler which started from a film roll, shaped it in a tube around the filling nozzle of the machine and sealed it vertically, filled the milk in the plastic tube and horizontally sealed into a pouch.

The system spread in many countries due to its light weight as one litre pouch requires less than 7 grs of PE film. So, its cost is very low. Further, it is an hygienic package; the plastic film is sterilized by UV rays in the filler.

The polyethylene film is also absolutely neutral. It is resistant to cold temperature. The pouch takes a minimum volume both for delivery to shops and also to be stocked in a refrigerator. The pouch is solid and can withstand a pressure of 100 kgs/cm^2. The milk can freeze in the pouch without breaking it. Further, to increase the mechanical strength of the film, a double layer film was made available.

In Canada, like France, the returnable glass bottle was the predominant milk container existent at that time. The new convenience of the disposable package helped it attain consumer acceptance, and today more than 50 per cent of Canadian milk is packed in flexible film bags and more than 100 IS-6 Fillers with an output of 5.000 pouches/hour are in operation.

Aseptic Packaging in India

A form-fill-seal system was introduced in India in 1965 to pack milk in flexible pouches. Now such machines are working today practically in all major cities packaging perishable products like Milk, Ghee, Vanaspati, Oils etc. in pouches.

Today such a system is in a position to give various models to pack different products in many sizes to suit different packaging materials.

Machines range from Manual Sealer for 400-500 pouches/hour to Twin-head machine with an output of 5,000 pouches/hour.

Due to the small weight of the plastic pouch, and its low cost, this system has been chosen by many countries, specially in the recent years in South America and Africa.

The pouch costs, in material one third of a carton, and as the film is manufactured in the user countries, it means a substantial saving of foreign currency, mostly US Dollars. More than 3,000 pouch fillers are in operation in 90 countries.

Aseptic Filler

To meet the requirements of UHT milk packaging, many years ago the design of an aseptic filler was started. Many prototypes were assembled and extensively tested by official laboratories, and also by the research centers of international milk companies in Europe and America.

The aseptic filler must have a sterile cabinet. To get it, you must sterilize the cabinet before operation, and keep it sterile when packing. Of course, the film must be sterilized before entering the sterile cabinet.

To get a sterile cabinet, it is better to locate the minimum amount of components inside, and also these components must be able to withstand the corrosive action of the sterilizing product as we use the most efficient one: hydrogen peroxide. Also, to be sure to keep sterility in operation, it would be unsafe to locate an air cylinder inside the cabinet as any small leak in the air circuit could introduce unsterile air, even if the leak is not significant and has no consequence on the mechanical performance of the machine. That means that you do not build a

sterile cabinet around the elements of an existing filler, but you have to redesign it completely, keeping in mind all the above mentioned principles.

So, the aseptic filler is made of an aseptic cabinet of high grade stainless steel. Inside the cabinet are the filling tube and the vertical and horizontal sealing elements, and also a pulling device for the film, but all the actuating air cylinders are outside this cabinet. The film is sterilized in an hydrogen peroxide bath and then dried by hot sterile air when entering the sterile cabinet.

Description of the pre-sterilization programme:

Before production, it is necessary each time to sterilise with steam the interior of the cubicle with hydrogen peroxide and the milk valves and butter tank. A programmer coordinates and times the operation of the presterilization circuits. The whole operation is divided into five sequences:

(a) T_1—hydrogen peroxide atomisation. This lasts about 22 min. With all the the doors of the machine closed, the unit produces a thick mist of H_2O_2 which fills the cubicle and reaches all the walls and mechanical parts in the cubicle.

(b) T_2—H_2O_2 contact which lasts 10 min. This is the contact time of the peroxide mist providing the sterilisation of the inside of the cubicle.

(c) Temperature elevation—During this sequence, the advance of the programmer is blocked by the pressure switch and all valves are open. The steam circulates throughout the milk circuit.

The pressure increases progressively and then stabilises at 2.7 bars (i. e. 140°C). The pressure switch then releases the programmer which moves on to the next sequence.

(d) T_3—steam presterilisation—when this begins at 2.7 bars constant pressure in the milk circuit. It lasts 25 min.

(e) T_4—cooling of the milk circuit and drying of the cubicle. With sterile air. It lasts 35 min. All the available valves are closed.

The steam circuit consists of condensate bleed valves which eliminate the condensates in the circuit during the phase temperature elevation and T_3. The milk circuit consists mainly of a milk supply valve, a solenoid valve and a buffer tank and two injection tubes.

The H_2O_2 circuit consists of a heating tank, and circuits concerning pulverisation and H_2O_2 tank filling.

The sterile air circuit consists of a bre-filler, fan, airheater, bacteriological filter and an aspirator.

Film Route

1. The film roll is placed at the back of the machine on the reel support.
2. A stretcher gradually unwinds the reel whilst ensuring a regular tension of the film.
3. The maker prints the manufacturing code.
4. As it enters the aseptic cubicle, the film goes through the hydrogen peroxide bath.
5. At its outlet from the bath, scrapers eliminate the major part of the sterilising liquid.
6. The film passes over 4 return rollers so as to be exposed to the laminal flux of the sterile hot air which completes the drying operation and maintains a slight overpressure within the cubicle.
7. The second stretcher pulls the film to advance progressively.
8. The guide permits the alignment and adjustment of the film tension on the shaper.
9. The "Wallet" type forming plates fold the film.
10. The vertical sealing jaw seals the film on one side, thus making a film tube around the injection tube.
11. 4 rubber rollers ensure the advance of the film tube.
12. The milk level establishes itself at the end of the injection tube.
13. The horizontal seal jaw seals and separates the full pouches.

14. The pouches come out of the cubicle and are conveyed towards the overpackaging station by a conveyor belt.

Trials on Aseptic Machine

In 1982, trials have been made in one of the largest European dairy's laboratory to control the quality of products packaged by a machine on 25 products and around 60,000 sachets.

Reliability was controlled as the machine was run many times 6 hours non-stop.

The film sterilisation was controlled and the data on concentration and temperature of hydrogen peroxide were proved. As the total length of the film in the hydrogen peroxide bath is 280 cm, the film remains in the sterilization bath for 21 sec. for one litre sachet and 48 sec. for 250 cc sachet.

It was also checked that the sterile dry air should be at 45°C in order that less than 1 PPM of hydrogen peroxide will be retained in the packed liquid.

Controls of the presterilization of the aseptic cabinet were effected using inoculated metal plates, some introduced in the machine, some kept outside the machine and the number of spores compared. When respecting the above mentioned sterilization conditions, the logarithmic spore reduction was more than 5 powers of ten.

Control of the sterilization of the film. About 20m of the film were inoculated by spraying with a suspension of spores. Afterwards the film was sterilized in the machine. From the sterilized film pieces of 5×5 cm were cut out at different positions of the film and the number of the surviving spores was determined. The sterilization treatment of the film, recommended in the operating manual of the machine using H_2O_2 concentration of 34% at 44°C gives a spore reduction of more than 5 decimal powers. This can be considered quite sufficient for the film sterilization.

Shelf Life

It is quite clear that the pouches packed on AS. 2 Aseptic Filler are aseptic—a standard double layer polyethylene film will enable the product to keep its aseptic quality for many months, but the organoleptic quality of the product may be affected by other factors than sterility. Some are very sensitive to light, oxidation or vapour transmission.

Normally, supplies are in at least a double layer PE black and white film to protect the product from light. For most products a 2 to 3 weeks shelf life can be reached.

For longer shelf life complex films must be used and chosen according to the product and also to the availability in the country of different plastic materials. For example, in one machine used in China, France and U.S.A. for Fruit Juices and films range from double layer black and white PE to 5 layer films.

For Milk the AS.2 is used in Canada and USA for extended shelf life of pasteurized milk and in Peru, San Domingo, Portugal, Spain, France and China for UHT Milk, using mostly double layer PE film for 2 to 3 weeks shelf life, due to the low cost of this film.

DISCUSSION

SESSION II—PACKAGING METHODS AND PERFORMANCES

Paper 1: Aseptic Packaging—*by Mr. Podselver, Prepack, France.*

Q. What is the expected shelf life of aseptic Milk packed in Indian conditions? Do we need to keep it cooled as in European conditions? (Devariya, Consulting Engineer, Bangalore).

A. Fresh milk can stand for 2 weeks in double layer polyethylene film and 3 weeks in PVC coated films. This can stand 25°C storage temperature.

Q. What is the difference in film for aseptic pack and pasteurised pack?

A. Double layer black and white film and plain pasteurized HDPE film are sufficient.

Q. Are traces of hydrogen peroxide left? If so, what is the safe level? (T. R. Gupta, CFTRI, Mysore)

A. Yes, Some traces are left. The safe limit is below 1PPM.

Q. Do you think for short storage of milk for a day double layer pouch is necessary? (K. Viswanathan, Jardine Henderson Ltd.)

A. Yes, double layer will have good mechanical resistance and also prevents development of leakages.

Q. Is your system restricted to handle films only? (K. Viswanathan, Jardine Henderson Ltd)

A. No, the machine could be modified, to suit other materials.

Q. Have you tried non-contact ultra-violet sterilization of the aseptic container and film? Will there be any change in the colour during storage of aseptically packed milk? (V. Padmanabhan, India Tin Ltd, Bangalore).

A. Yes, U. V. sterilization is quite insufficient and the product wont stand. As far as colour is concerned, no change was noticed over a period of 6 months. However, the data was collected under European conditions.

Paper 2: Some corrosion factors in canned foods—*by P. Marsal, French Tinplate Research Centre, France.*

The following comments were made by Dr. M. Mahadeviah during the discussion:

A lot of work has been done at C.F.T.R.I. on this line. Heavy corrosion was noticed in canned papaya slices. This was found to be due to the nitrate content in papaya. IVy gourd having a pH of 4.8 has a nitrate content ranging from 100 ppm to 300 ppm which causes heavy corrosion in plain cans. If Epoxy Phenolic lacquered cans are used, slight lacquer taste was noticed after 9 months storage life. If polyester lacquer is used, this problem can be overcome.

Paper 3: Packaging and storage studies of partially defatted coconut gratings—*by Satyavathi Krishnankutty. RRL, Trivandrum.*

Q. Is there any method of preserving co-conut water, the by-product obtained in the desiccated co-conut industry? (R. V. Gowramma) CFTRI, Mysore)

A. Yes. We have developed a process for bottling of Co-conut water.

Paper 4: Aspetic Packaging—a new system for the integrity in bag-in-box packaging—*by Alastair Stephen*

Q. What is the packaging cost by changing the barrier material? (H. B. N, Murthy, Bangalore)

A. If polyester is used it does not make much difference. If metallised films are used it will be costlier.

Q. For bulk packaging of wine what is the capacity of the bag used? (Roberts from Voltas)

A. 20 litres capacity bag is used. It takes a lot of strength.

Q. Are you planning other products than milk? (A. C. Batra).

A. We have tried several other products. Of them the most difficult product is tomato puree which has been successfully filled.

Q. In the case of Bag-in-Box packing what type of Box is used?

A. It depends on the quantity. Mostly galvanised Iron drums are used.

Q. What is the cost of filler? (P. V. Raju, CFTRI, Mysore)

A. 50 to 60 thousand dollars.

Paper 5: Studies on the storage life of cod fillets—*by T. K. Srinivas Gopal, CFTRI, Cochin.*

Q. Can this be applied for shrimp packaging? (Shanthi Narasimhan, CFTRI, Mysore).

A. Yes, but it will be expensive.

Q. What is the size of the packet?

A. It is 18 Cm×5 cm×5 Cm, Gauge 400μ

Q. Since the cost of this type of packaging is high, what relevance has this to India? (Viswanath)

A. Yes, it is costly. About 2 croners (Rs. 3). If it is developed indigenously, it may become cheaper.

Q. What is the necessity of using CO_2 and Oxygen in the ratio 50:50. Is it not possible to reduce the CO_2 content? (P. V. Raju CFTRI)

A. 20% CO_2 is sufficient for enhancing the shelf life. Part of the CO_2 is converted to Carbonic acid in the product, thereby CO_2 level goes down. If CO_2 is too low, *Pseudomonas* spoilage occurs. The safer side is to put 50% CO_2.

Q. Why is LLDPE not used?

A. It is very costly.

Paper 6: Corrosion of aluminium container with processed food products—*by R. Naresh, CFTRI, Mysore.*

Q. Is it economical for packing fish? (Sreenivas Gopal)

A. If small size cans are required aluminium cans are cheaper. For larger packs, tinplate cans are cheaper.

Q. Aluminium cans are costly, why? (Kumaraswamy)

A. For the production of aluminium cans, energy utilisation is very high and hence it is costly. But aluminium cans can be recycled, thereby reducing the energy cost.

Paper 7: Recent trends in packaging of oils in flexible consumer packages—*by Baldev Raj, CFTRI, Mysore.*

Q. What is the P V value of market sample? (R. V. Gowramma, CFTRI)

A. In our experience lot of variation was noticed.

Q. What is the sealing characteristic of Surlyn Nylon? Is it not bad? (Viswanath)

A. Yes, definitely. We could not get good results. Some sealing defect is there. It has to be improved.

Q. Is there any comparison of TBA and PV?

A. We are not sure, a lot of data has to be collected. Peroxide value took a sharp rise at 25 meq/Kg of Oil.

Q. Based on your study would you recommend use of LDPE film for packing oil for limited shelf life requirement? (P. R. Sheshan, IPCL, Baroda)

A. 40 days shelf life can be expected. LDPE may develop leaks.

Paper 8: Packaging & Storage studies of desiccated coconut in Flexible packages—*by A. R. Indiramma, CFTRI, Mysore.*

Q. What is the specification of Metallised poly and Polyethylene?

A. It is 12 μ Metallised Polyester/150 Gauge Polyethylene.

Q. What is the W V T R for Metallised Poly?

A. It is 0.8 gm/Sq. Meter/day under 90% R. H Gradient at 38°C.

Q. How do you explain a lower shelf life of desiccated coconut in vacuum pack? (Vijay Toley, Rollatainers Ltd, Faridabad).

A. In vacuum packages there was shrinkage. Delamination also occurs because of hydrophilic nature.

Paper 9: Polyethylene bag packing for carbonated curd—*by S. P. Panda, P. K. Vidyaraih, Akola.*

Q. What about the control without CO_2?

A. It won't store even for 2 days. Carbonation creates anaerobic conditions and increases the shelf life.

Q. Have you measured CO_2 content with stored material? will it not dissappear after sometime?

A. CO_2 estimation has not been carried out during storage. But dissolved CO_2 may still be there. Shelf life was found to be 1 month.

Paper 10: Packaging performance Assessment in Beverages by sensory analysis —*by Shanti Narasimhan*

Q. How do you apply this method for solids/dry powders? (Vijay Toley, Faridabad)

A. Dilution can be done. Same principle can be applied. Spent material can be used for the above.

Q. What is the specific reason for using HDPE for packing the material?

A. There is no particular reason. Similar studies can be done with other packaging materials also.

Q. Was there any change in colour? Have you used any coal tar colour?

A. Yes, coal tar colours were used. Only commercial samples were used for the study which contained coal tar dyes.

Paper 11: Package performance—*by S. Venkataraman, IIP, Madras.*

Q. How do you achieve scratch resistance in light weight glass bottles? (P. V. Raju, CFTRI, Mysore)

A. By silicone coating scratch resistance can be improved.

SYMPOSIUM SESSIONS

SESSION III—TRANSPORT PACKAGING

Chairman: Dr. H. B. N. Murthy
Co-Chairman: Sri. P. V. Raju

Rapporteurs: Dr. D. Narasimha Rao
Sri. B. Mahadeviah

New trends on the use of plastics in packaging

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ABSTRACT

Though packaging industry is still dominated by traditional materials, plastics due to their versatility, have already made inroads into the traditional areas of packaging. In industrially advanced countries, remarkable growth in packaging has been made possible due to availability of a variety of thermoplastic materials coupled with developments in conversion techniques. In the Indian context, though some of the techniques are already in use, with the increasing cost of the traditional material, lot of scope exists for adapting latest processing techniques for manufacturing packaging material. In this paper, a review of new trends on the use of packaging material is covered.

In India, packaging industry is still dominated by traditional materials like paper, glass, wood, metal, etc though some of the plastics were indigenously manufactured since 1960. However, during the last two decades, with the increasing availability of a variety of plastic raw materials coupled with the change in concept of packaging, plastics are increasingly used in various forms for packing food and allied products. This paper reviews the latest trend on the use of plastics as a packaging material.

Classification of Packaging Material:

Flexible:

—Film: These include the following in general:

Unsupported film bags, pouches, sachets from Low Density and High Density Polyethylene films, cast and oriented PP films, heavy duty bags from LDPE, paper like films from HDPE.

—Laminates: Super imposed structure of paper, plastics or foil bonded together by heat/adhesive or polymer melt forming a composite structure of uniform thickness and Flexibility.

—Co-extruded films: Basically two or more polymeric material from different extruders are fed to the common die and the film emerging out as a single layer. The number of layers will be minimum two.

Semi-rigid:

These cover items manufactured by extrusion or blow moulding process like collapsible tubes and thermoformed containers.

Rigid Packages:

These include blow moulded hollow wares, injection moulded containers.

New Trends in Packaging in Developed countries:

Flexibles:

Co-extrusion: There are primarily two routes to obtain co-extruded structure i. e. blown film process and flat die technique.

In both the processes, basically two or more polymeric materials from different extruders are fed to the common die and the films emerging out as a single layer. This is done by uniting the plastic resin inside the die head. In many cases, normally a bonding layer is used to obtain a good adhesion between different polymeric materials.

With the extruder system, it is possible to produce a five layer composite structure. With this technique, the merit of individual materials can be united to form a composite in single operation thereby eliminating secondary processes which are normally re-

quired for other lamination techniques. The structural layers are normally based on LDPE, LLDPE, HDPE and the barrier layer is usually PVDC EVOH and Polyamides. The bonding/tie layer is usually a co-polymer based on polyolefin or ionomer.

The use of a five layer co-extruded structure in flexible packaging of food enables the reduction in thickness upto 30% in the barrier layer and also use of a cheaper barrier layer e. g. Nylon-6 instead of copolymer of Nylon used in 3/2 layer structures for the same functional requirements. In addition, the curling of the composite structure is considerably reduced due to symmetrical structure and the barrier properties are improved due to embedded barrier layer. In addition, the film can be sealed on either side. This type of composite structure is primarily used for food packaging e. g. snack food, cheese, sausage, cold cuts, fish, meat, pre-cooked meals, etc.

Use of three layer extruded film LD/HD/LD, LD/MD/LD, LD/LLDPE/LD for the manufacture of heavy duty films has resulted in reduction of thickness from 200 microns to 130 microns for the same functional requirements.

Co-extruded BOPP with a sealing layer based on terpolymer of PP has resulted in increasing the sealing range and reduction in heat initiation temperature thus giving a versatile film for using in different types of FFS machine for packing snack foods, tobacco, etc.

Biaxially oriented nylon co-extruded with LLDPE sealant layer offers extended shelf life, flexo-crack and abrasion resistance, high level of seal integrity, consistency and puncture resistance for food products to be distributed over long distances.

Improved metallizing techniques have enabled development of metallized OPP and OPET films with improved gas and moisture vapour barrier properties and very low light transmission. Shelf-life of potato chips packed in this type of metallized OPP has been improved from 6 months to 9 months. Established applications of metallized films include packaging of coffee, tobaco, snack foods, ice-cream, yogurt, biscuits, cakes, deep frozen foods, milk powder, cheese, ketchup, etc.

In USA market of BOPP in flexible packaging sector is continuously growing. The estimated consumption of BOPP in 1983 is 95,000 Tonnes and BOPP is mainly replacing cellophane. Cellophane industry being highly energy intensive, the cost of cellophane is likely to go up steadily, widening its price gap with BOPP. In Japan, 59,000 Tonnes out of 110,000 OPP film produced in 1982 went in food packaging. Nearly 40-50% of all food stuffs will be packed in fully prepared form according to US Government projections. Such food will only require preheating before serving. New generation co-extruded OPP structures using the heat sealable layers are expected to share greatly in this market. The consumption of PP may go upto 10 MM lbs.

Certain recently developed 5 layer structures based on PP and PP opaque cellular films may threaten glassine in snack food overwrapping market. However, there is another strong contender for this market in the form of co-extruded structures based on LLDPE and HDPE.

Co-extrusion coatings:

Like co-extrusion blown film and cast film, use of high barrier co-extrusion coatings consisting of 4-5 layers is increasingly becoming popular. The advantages of such system are:

selection of wide range of base material including paper, foil and cellophane.

possibility of reverse printing for better sales appeal.

for the same conventional requirements, co-extrusion coatings is claimed to be cheaper than the other systems.

with the development of coating technology, it will be possible to replace foil, glassine paper and cellophane with other plastic film in the laminate structure.

Semi-rigid containers:

Multilayer sheets are normally used for manufacturing semi-rigid containers by thermoforming. The structural layer used for these sheets are PP, HDPE, HIPS while the barrier layer is either PVDC or EVOH.

In case of gas flush packaging, a co-extruded sheet based on PS/EVOH/PE of 0.6mm used for thermoforming trays while a lid of Aluminium Foil/PE is used for packing products like meat, poultry, vegetable salads, pastry, etc., for a shelf life of one week for meat and poultry and three weeks for

salads and pastry. Such containers are also replacing metal cans.

In case of aseptic packaging, containers from co-extruded sheets of PS/Tie/EOH/Tie/PE are used for thermoforming trays while a lid of lacquered foil is used for packing products like fresh food, cream, processed cheese, etc. for a shelf-life upto one year. This again is used as a replacement for metal cans. In Europe, PP/EVAL/PP structures are also being commercially used for hot fill aseptic barrier applications.

Pasteurization and retort sterilisation applications are finding use of PVDC barrier containers in the form of PP/PVDC/PP as symmetrically co-extruded structure.

In case of retortable packing, thermoformed containers are manufactured using co-extruded structure PP/Tie/PVDC/Tie/PP with a seamed easy opening Aluminium top for packing delecatessen meat and fish products for more than twelve months sheif-life. An improved version of the same composite has been developed and commercialised recently by M/s. Cobelplast, Belgium. This composite is used in thermoformed packaging with high gas, water and odour barriers for food including meat, with a two-year shelf-life.

In Japan, PA/EVAL/PP/PET composite is used as a transparent retortable pouch structure and PP/EVAL/PP composites are used for a wide variety of products including retortable cans for mushrooms, corn and fruits. PP/EVAL/PP trays are also widely used in UK. Other composites containing EVAL in use world-wide include OPP/EVAL/PE (dehydrated fish), PS/EVAL/PP (marmalade), LDPE/EVAL/LDPE (mayonnaise) and HDPE/EVAL/HDPE (Salad oil). Other possible structures under examination are PS/EVAL/PS (dairy products), PP/EVAL/PP (hot fill liquids) and PS/EVAL/PP fruit juices). Similar composites involving high barrier PVDC, popular world-wide include LDPE/PVDC/PS (butter), PS/PVDC/PS (fruit juices), PET/PVDC/PE (snacks) and PVDC/PE/Polybutadiene (scrambled eggs.

Rigid Containers

Stretch blown containers:

These special techniques have been developed in recent years to increase the strength of containers made from polymers like PVC, PET and PP by biaxial orientation. This involves stretching the material while hot melt is held within a narrow temperature range in both longitudinal and transverse direction so as to increase its strength and improve the properties such as stiffness, tensile, impact resistance, gas or vapour resistance, burst strength, and transparency, etc. These properties are significantly improved due to the biaxial orientation even at lower wall thickness compared to conventional blow moulded bottles and hence considerable reduction in weight of the bottles are possible. Bottles manufactured by this method are suitable for packing lightly carbonated drinks and other products which are pressurised and normally packed in glass bottles or metal cans for a limited shelf life. Such blown containers can be manufactured either by injection blow moulding, extrusion blow moulding or by a two-stage process namely coroplast system i. e. manufacture of tube first and subsequently pre-heating and biaxial stretching of the tube to form bottles by blowing. Recently, 1.5 litre PVDC coated PET wine bottles have been commercialised in USA. 3 and 4 litre wine bottles are currently under trial. A debate is going on whether an oxygen barrier coating is required because of low surface to content ratio in such containers. Clear PET squeeze bottle (12 oz) has been recently developed for mustard packaging adopting the same technique. Monsanto is developing hot fillable PET bottles which can withstand filling temperature upto 195°C. This is being done by a complicated technique where crystallisation of PET is allowed only half way during bottle moulding.

OPP blow moulded wide mouthed jars are replacing glass jars for spices where the flavour retention characteristics of OPP is utilised.

Multilayer containers:

In case of rigid containers like bottles, jars, etc., the structure layer is mainly HDPE, LDPE, PP and PVC and the barrier layer is either coatings based on PVDC or chemical modifications by flouro-carbon layer or a co-extrudable barrier layer based on Nylons, EVOH, PVDC, etc.

Use of multilayer blown containers for packing of foods and beverages are becoming very popular in advanced countries and these can be produced from co-extruded tubes, co-extrusion blow moulding and co-injection blow moulding. Co-extruded tube of 3.75 mm wall thickness based on a structure of modified PET/50 micron Tei layer/125 micron EVOH/50 micron Tie layer/Modified PET is used to manu-

facture stretch blown bottles of 0.3mm wall thickness. Such bottles are suitable for packing carbonated beverages where shelf-life upto 16 weeks are required, very low O_2 transmission is necessary and these bottles can be reused like glass bottles.

Co-extruded blow moulded bottles of structure PP/Tie layer/ EVOH/Tie layer/PP is used for packing liquid food products like barbecue sauce for shelf life upto 40 weeks. Co-extruded OPP bottles lack optical clarity but the contact clarity is sufficient for the display of the contents.

The technique of co-injection moulding is still in developmental stage even in advanced countries.

Tubes from co-extruded structure PET/Tie/EVOH/ Tie/PET with easy opening seemed Aluminium ends on both sides is used for packing hot filled product which can be retortable replacing metal containers.

Use of polycarbonate in packaging:

The polycarbonate is traditionally an engineering thermoplastic. Extensive developmental activities are being carried out by the resin manufacturer on the use of polycarbonate in co-extruded structure in film, semi-rigid and rigid packaging.

Advantage of polycarbonate in co-extruded film structure are that due to the inherent property of the polymer, it can be included in the structure as one of the co-extrusion layers. There is no need for any orientation and heat setting of the film for developing the properties like clarity, strength, etc. as required in case of films like OPP and OPET.

Its use in semi-rigid co-extruded structure as one of the layers are its improved heat resistance allowing higher retort temperature and retention strength even after retorting, improved clarity, better printability and easier thermoformability.

In case of rigid containers, use of polycarbonate as one of the layers e.g. inner layer, enables the product to be hot filled even at higher temperatures. As an outer layer, it can be hot sterilized without the loss of clarity and hence can be re-used. In addition, polycarbonate as an outer layer provides better clarity and easy printability. It is anticipated that the use of polycarbonate in co-extruded structure will be commercialised shortly in view of the above advantages inspite of the fact that the cost of base polymer will be much higher compared to other polymers used in packaging at present. Tremendous future potential is anticipated for metallized retort packages and a composite structure of metallized polycarbonate film and a barrier co-extrusion of tie layer/EVOH/tie layer/PP is being developed. A polycarbonate/Tie layer/LDPE structure may replace conventional laminates of cellulose/LDPE, BOPP/ LDPE and OPET/LDPE in the general packaging sector. It may also replace 12 micron Polycarbonate/ 12 micron Tie layer/25-50 micron EVA in medical disposable applications.

Conclusion

This review mainly covers the latest trends in packaging that are taking place in advanced countries. In India, the conventional materials like glass and tin dominate the packaging industry. With the availability of newer type of thermoplastics coupled with the ever increasing price of traditional materials and with the machinery developments, some of the processes described are likely to be commercialised in India as well. This will no doubt enhance the packaging concept in our country.

Commerical Trials on Transport Packaging for Selected Fruits

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ABSTRACT

With a view to develop a National Standardised Economy Fruit Box and to assess the monetary benefits accruing to the producer-seller as well as the consumer with the introduction of improved packages, commercial trails are being conducted on a few selected fruits by the Market Planning & Design Centre, Nagpur. The results presented in this paper are the outcome of the studies conducted on apples from Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh and on Nagpur Mandarine Oranges.

Though India's fruit production and growth has been encouraging during the recent past and considerable advance has also taken place in the field of marketing of fruits, their efficient physical distribution from the producing areas to the consuming centres remains a major problem. The perishable nature of fruits renders physical distribution more challenging. The high fluctuation in the seasonal prices also poses a number of economic problems. The present system of transporting, handling and packaging of fruits also result in significant losses. Adequate packaging is necessary for the successful distribution of perishable commodities, especially in relation to transport systems and hazards. It is also desirable that the package should add as little as possible to the transport cost of the produce it contains.

With wood becoming more and more scarce, the wooden boxes which are most commonly used now for fruit packaging have become more expensive and re-usable boxes will have to be used as a matter of necessity as it results in greater saving of wood, the primary raw material and consequently in lessening the rate of felling of trees.

While discussing the benefits of packaging we should note that packaging cannot improve quality; therefore, only the best possible produce should be packed. Inclusion of decayed or damaged fruit in the packages would affect adversely the sales at the market or would become a source of contamination or infection to healthy fruits. The package must provide adequate protection against moisture loss but should not seriously impede exchange of oxygen and carbon-di-oxide nor the removal of vital or sensible heat. Over-packaging is to be avoided as under-packaging. The package must accommodate packs of fruit which are neither so tight as to cause bruising nor so loose as to result in friction or abrasion damage. As such, good packaging should cater to the demands of the product and be as inexpensive as possible.

The marketing agencies dealing with fruits in India could not make any significant dent in the realm of packaging to increase the marketing efficiency. The growers in general and the small growers in particular seldom receive remunerative price for their produce. Consumers seldom get quality fruit at a reasonable price. The present system of packaging of fruits also results in significant losses.

With a view to harvest the fruit at right maturity period depending upon the distances to be transported, improving transport packaging system and to help the cultivators get a better price and to make available the better quality fruits to the consumers at a reasonable price, the Market Planning and Design Centre (MPDC) under the Union Ministry of Agriculture & Rural Development at Nagpur has successfully conducted a few commercial trials on Transport Packaging on a few selected important fruits and obtained encouraging results.

The trials conducted on Apples and Oranges are discussed in this paper.

Packaging Trials on Apples:

Apples are traditionally packed in wooden cases. The wood required for packing these apples is very

huge. About 3 crore wooden boxes are used every year to market the apple crop which requires about 3 lakh cubic metres of wood. At the present rate of consumption the requirement of boxes would double by 1990. Another estimate is that each hectare of apple orchard needs about 3 hectares of spruce and silver forest. Illicit felling of trees has also obliterated the prospects of essential requirement of wood. As the production of apple increases, the demand for wood for packing cases would certainly outstrip the actual supply position. Under the circumstances the MPDC tried to introduce alternate packages for transporting apples during the years 1980, 1981 and 1982 under its Apple Trade Development Project. In the year 1980, an attempt was made to introduce a new package in 3 important apple growing States of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh. The imported corrugated telescopic tray pack cartons were tried along with local tray pack cartons, bushel box and conventional wooden boxes in 7 trials between Jammu and Kashmir and Delhi; Himachal Pradesh and Delhi; and from apple growing areas in Uttar Pradesh to Lucknow during the period from August to December 1980. In these trials the new type of package, namely, tray pack cartons faired better than the conventional wooden boxes. The introduction of tray packs could eliminate to some extent the wasteful and time consuming practice of re-packing at Azadpur (Delhi) for onward despatches. In these trials no empirical study could be made as the main aim was to make the concerned marketing agencies accept the new package. However, the trials revealed that rats could find an easy entry into these packs through slits on the sides provided for lifting the cases; as a result a number of fruits in tray packs were found to have been eaten in the pack. This could possibly happen at the packing station and transhipment area or even at terminal market.

Encouraged by the preliminary experimental trials in 1980, bigger programmes of commercial trials were organised in the years 1981 and 1982. About 15 trials were conducted during the period from September 1981 to December 1981. A sample study on bruising was also made in these trials. The result of this study has been summarised in Table—1.

It may be observed from the Table that the cartons with tray packs have shown better results than the conventional wooden boxes. But the economics of cartons in the context of traditional wooden boxes has not been satisfactorily established. As a result of these trials, all the three major apple growing States have agreed in principle to use cardboard cartons for packing at least at the institutional level to begin with and in Azadpur market which is an important terminal market for apples, the carton packing is well-known now. The Himachal Pradesh Govt. has now decided to stop the supply of timber for making apple boxes at concessional rate by 1990 and efforts would be made to popularise the cardboard boxes for packing purposes (Financial Express., dated 31-7-1984). If the quality standards for selected varieties of apples are uniformly maintained, tray pack is likely to bring definite transformation in the transport packaging.

Trials on Oranges:

Chemical Treatment: The MPDC in collaboration with the NAFED conducted a transportation trial in March 1982 relating to post-harvest technology from Savargaon village (Nagpur area) to New Delhi (1,100 kms). The aim of the trial was to assess the actual quality losses for oranges during transit. Grading of oranges was done in accordance with the standards laid down by this Centre. The treated and untreated oranges were accommodated in four compartments in one truck as detailed below.

Control—(Untreated fruits).

Benlate—50 (0.10%) Treated).

Waxol-0–12 emulsion (6%) and Benlate-50 (0.10%) (Treated).

Bavistin (0.05%) (Treated) (Active principle 50%).

The truck load of oranges in bulk was despatched from Savargaon on 21-3-82 at 22.00 hrs. and the truck reached Delhi on 24-3-82 at 22.00 hrs. Thus the truck took 72 hours to reach Delhi. The transit temperature varied from 16°C to 37.3°C.

The fruits were unloaded compartment-wise and sorted out at the destination into:

Good fruits.

Crushed fruits.

Skin broken fruits, and

Rotten fruits.

Compartment-wise analysis of fruits is given in Table No. 2. It is evident that highest percentage of fruits (76.82) were noticed in compartment "C" (Benlate and Waxol-0-12 emulsion). While the lowest was in Control with 44.21%, the Bavistin

Table 1. Extent of bruising of apples in different types of packages

Consignments	Sample No. of box	Bruising in per cent		
		Slight	Moderate	Severe
Kulu to Azadpur/Delhi (September 1981):				
Local tray pack	10	0.7 to 2	1.3	—
Conventional wooden box	10	1.2 to 8.1	1.2—5.6	1.2 to 2.4
Kulu to Azadpur (Sept. 81):				
Local tray pack	10	1.6—5	0.7—1	—
Kulu to Azadpur (Sept. 81):				
Local tray pack	7	1.6—4	—	—
Conventional wooden box	3	2.9—4.5	—	—
Kulu to Azadpur (Sept. 81):				
Imported tray pack	10	1.6—5	0.8—4	0.7—1.6
Kulu to Azadpur (Sept. 81):				
Conventional wooden box	10	4.7—11.1	1.7—4.7	1.6—1.7
Kulu to Azadpur (Oct. 81):				
Imported tray pack	18	0.7—6	1.0—2.7	—
Conventional wooden box	30	2.4—12.5	1.2—5.6	—
Kulu to Azadpur (Oct. 81):				
Local tray carton	2	1.3—2.2	—	—
Imported tray carton	3	2.0—4.0	—	—
Conventional wooden box	25	1.2—9.5	1.2—12.3	—
Kulu to Azadpur (Oct. 81):				
Imported tray pack	6	1.3—7.0	0.7—2.4	0.8—1.3
Conventional wooden box	45	1.2—12.1	0.5—7.0	0.9—6.2
Kulu to Azadpur (Oct. 81):				
Local try pack	15	1.3—3.2	—	—
Kulu to Azadpur (Oct. 81):				
Tray pack (Local & Imp)	6	1.3—2.7	—	—
Conventional wooden box	14	1.0—8.3	1.2—2.8	—
Kulu to Azadpur (Oct. 81):				
Local & imported tray pack	27	0.7—4.8	0.7—2.0	0.7—5.0
Kulu to Bombay (Nov. 81):				
Tray pack (local & imp.)	3	2.4—12	2.0—3.0	0.8—4.0
Conventional wooden box	7	6.6—39.2	2.0—13.3	2.6—14.2
J & K Chachkhanhan to Delhi (Nov. 81):				
Local & imp. tray pack	31	0.7—16.3	0.5—11.3	0.7—7.5
J & K Zakura to Delhi (Nov. 81):				
Imp. & Local tray pack	31	2.1—28	2.1—36.3	1.3—17.1
J & K De Delhi (Dec. 81):				
Imp. & Local tray pack	27	1.4—19	1.4—12.7	1.5—11.1
Conventional wooden box	3	9.2—15.2	1.6—12.3	7.6—9.2

Table 2. Losses During Transit (Nagpur Mandarine oranges despatched from Savargaon village (Nagpur area) on 21—3—82 and arrived in Delhi on 24—3—82

Total No. of fruits: 83,030

Sl. No.	Compartments	Type of treatment	Good fruits	Crushed fruits	Skin broken fruits	Rotten fruits	Total
1.	A	Control-untreated	11,976 (44.21)	8,921 (32.93)	720 (2.66)	5,472 (20.20)	27,089 (100.00)
2.	B	Benlate-50 (0.10%) treated	12,832 (54.84)	7,600 (32.48)	550 (2.35)	2,417 (10.33)	23,399 (100.00)
3.	C	Waxol-0-12 emulsion (6%) and Benlate-50 (0.10%) treated	12,538 (76.82)	2.057 (12.60)	420 (2.57)	1,308 (8.01)	16,323 (100.00)
4.	D	Bavistin (0.05%) treated	11,193 (69.00)	2,320 (14.32)	366 (2.26)	2,340 (14.42)	16,219 (100.00)
		Total	48,539 (58.46)	20,898 (25.17)	2,056 (2.48)	11,537 (13.89)	83,000 (100.00)

Note: Figures in parenthesis indicate percentage to the respective total.

treated compartment stood second highest with 69 per cent of good fruits and Benlate-50 treated had 54.84 per cent of good fruits. In the case of crushed fruits, the compartment treated with Waxol-0-12 and Benlate-50 performed better with only 12.60 per cent. It was maximum in Control with 32.93 per cent. In the case of rotting also, the percentage of Benlate and Waxol-0-12 emulsion treated fruits was the lowest (8-01%). It was 10.33 per cent for Benlate treated and 14.42 per cent for Bavistin treated fruits, while in Control the rotting was the highest with 20.20 per cent.

Packaging: Five experiments on packaging with re-usable wire bound boxes, HDPE crates, solid board cartons and traditional wooden boxes on oranges were conducted between Nagpur and Bangalore in 1984, with a view to estimate losses due to driage and damages during transportation and to study the comparative advantages in using the different improved packages. One experiment in April 1984, two experiments in November 1984 and two experiments in December 1984 were conducted in collaboration with the Bangalore Horticultural Producers' Marketing & Processing Co-op. Society Ltd., with the co-operation of Shri Wasudeo N. Deshpande, a progressive orange grower at Warud, near Nagpur. The wire bound boxes, plastic crates and solid board cartons were supplied to the orange grower by the MPDC free of charge. The benefit of the cost of these packages went in favour of the orange grower and the Bangalore Co-op. Society.

The first consignment in the month of April 84 was despatched from Pandhurna where the oranges packed whereas all the remaining four consignments during the current crop season were despatched from the orange gardens at Warud. The oranges were sold direct to the consumers through 20 retail outlets of the Society in Bangalore City and 10 outlets in Mysore City. During April 1984 the consumers could get quality oranges at Rs. 4.50 per kg. as against the then prevailing retail price of Rs. 5.00 to Rs. 6.00. Though oranges were sold at Rs. 4.50 per kg., the account to the farmer-seller was settled at Rs. 4.00 per kg. in view of the fact that loss due to driage and damage was experienced during the retailing period of three days after the consignment reached Bangalore. The Society was allowed to charge 50 paise per kg. from the sale proceeds to compensate all such losses and the expenses incurred for transporting oranges to different retail outlets in Bangalore and Mysore Cities.

In the month of November and December 1984 oranges were sold to the consumers at Rs. 4.00 per kg. as against the then prevailing price of Rs. 6.00 to Rs. 8.00 per kg. during November 1984 and Rs. 5.50 to Rs. 6.50 per kg. during December 1984.

The different components of the cost of marketing of all the five consignments as shown in the Case Studies I to V have been analysed in Table—III. The results of these trials have been summarised and shown in Table—A.

CASE STUDY—I

Orange grower harvesting Nagpur Mandarine oranges at Warud on 2nd & 3rd April 1984, grading and packing at Pandhurna on 4-4-84 (night) and selling them to the consumers direct in Bangalore and Mysore through the Bangalore Horticultural Producers & Marketing & Processing Co-operative Society Ltd. during 9th Apr. to 13th Apr. 84.

The truck left Pandhurna on 6–4–84 (night) and reached Bangalore on 9–4–1984.

Type of boxes	No. of boxes		No. of oranges in each box	Total No. of oranges
Wire-bound boxes	8		64	,512
"	125		72	9,000
"	92		80	7,368
"	192		92	17,664
"	43		100	4,300
"	23		106	2,438
"	14		112	1,568
Total	497	Av.	86.20	42,842
Traditional wooden boxes	14		96	1,344
"	10		112	1,120
"	6		165	990
Total	30	Av.	115	3,454
Grand Total	527			46,296

At Bangalore on 9-4-1984:

Total weight of oranges (net) received:

(*i*) In wire-bound boxes: 497×12.64=6,282 kgs

(*ii*) In ordinary boxes: 30×17.5 = 525 kgs

Total: 6,807 kgs

(The Av. No. of oranges per kg is 6.8)

Deduct damages:

(*i*) In wire bound boxes: 497×1.15=572 kgs

(*ii*) On ordinary boxes 30×3.4=102 kgs. 674 kgs

Total weight of good oranges: 6,133 kgs

Total sale value booked by the Bangalore Horticultural Producers & Marketing & Processing Co-operative Society Ltd. at Rs. 4 per kg. Rs. 24,532

Deduct total expenses:

(1) Commission @ 10%	Rs. 2453	
(2) Labour @ 0.40 p per box	Rs. 211	
(3) Transportation from Pandhurna to Bangalore	Rs. 4700	Rs. 7,364
Amount received by the Orange Grower:		Rs. 17,168
Deduct cost of harvesting, packaging etc.		Rs. 2,525
Nat amount realised by the Grower:		Rs. 14,643
The price at Warud on 6–4–1984 for 1000 oranges:		Rs. 225
The price for 46.296 oranges:		Rs. 10,416.60
The incremental benefit to the orange grower:		Rs. 4,226.40

CASE STUDY—II

Oranges harvested at Warud on 8th, 9th and 10th November 1984. Graded and packed on 9th and 10th November 1984 and sold to the consumers direct in Bangalore and Mysore through the Bangalore Horticultural Producers' Marketing & Processing Co-op. Society Ltd., Bangalore, during 14th November to 1st December 1984.

The truck left Warud on 11-1-1984 and reached Bangalore on 14–11–1984 early morning.

Type of boxes	No. of boxes	No. of oranges in each box	Total No. of oranges
Wire bound boxes	48	72	3456
"	47	80	3760
"	286	93	28028
"	12	100	1200
"	72	112	8064
Total	465	Av. 95.72	44508
Plastic crates	11	84	924
"	10	99	990
"	49	160	7840
Total	70	Av. 139.34	9754
Traditional wooden boxes	30	148	4440
Grand Total	565		58702

At Bangalore:

Total weight of oranges (net) received:

(*i*) In wire bound boxes: 465×14.47=6729 kgs.

(*ii*) In plastic crates: 70×18.30=1281 kgs.

(*iii*) In traditional wooden boxes 30×24.13= 724 kgs.

Total 8734 kgs.

(Average No. of oranges per kg. is 6.72)

Deduct damages:

(*i*) In wire bound boxes: 465×0.980 kgs.=456 kgs.

(*ii*) In plastic crates: 70×1.970 kgs.=138 kgs.

(*iii*) In traditional wooden boxes 30×5.420 kgs.=163 kgs.

Total 757

757 kgs.

Total weight of good oranges 7977 kgs.

Damages allowed for retail outlets @4% 319.00 kgs.

Quantity booked for sale value: 7658.00 kgs.

Total sale value booked by the Bangalore Horticultural Producers: Marketing & Processing Co-op. Society Ltd., Bangalore. @ Rs. 3.50 per kg. Rs. 26,803.00

Deduct: Total Expenses:

1. Commission @ 8%	Rs. 2,144.24
2. Labour @ 0.40 per box	Rs. 226.00
3. Transportation from Warud to Bangalore	Rs. 4,152.00
	6,522.00
Amount received by the orange grower	Rs. 20,280.76
Deduct: Cost of harvesting, packaging, etc.	Rs. 1,390.00
Net amount realised by the grower	Rs. 18,890.76
The price at Warud on 9–11–1984 for 1,000 oranges	Rs. 150.00
The price for 58,702 oranges	Rs. 8,805.30
The incremental benefit to the orange grower	Rs. 10,085.46

CASE STUDY—III

Oranges were harvested on 16th, 17th, 18th, 19th, 20th and 21st November 1984, packed on 20th, 21st and 22nd at Warud.

The truck left Warud on 22—11—1984 at 14.00 hrs. and reached Bangalore of 24—11—1984 at 06.00 hrs.

Type of boxes	No. of boxes	No. of oranges in each box	Total No. of oranges
Wire bound boxes	5	48	240
"	6	72	432
"	44	80	3520
"	10	90	900
"	15	91	1365
"	99	92	9108
"	127	100	12700
"	27	112	3024
"	92	150	13800
Total	425	Av. 106	45089
Plastic creates (grey)	6	128	768
"	29	132	3828
Total	35	Av. 131	4596
Plastic creates (yellow)	11	132	1452
"	4	156	624
Total	15	Av. 138	2076
Plastic crates (red)	2	132	264
"	26	147	3822
"	24	156	3744
"	8	180	1440
Total	60	Av. 155.5	9270
Total No. of plastic crates	110	—	15942
Traditional wooden box	15	158	2380
Grand total	550	—	63401

At Bangalore:

Total weight of oranges (net) received:

(*i*) In wire bound boxes:	425..13.09=	5563.25 kgs.
(*ii*) In plastic creates		
(*a*) Grey	35×25.25=	883.75 kgs.
(*b*) Yellow	15×19.74=	296.10 kgs.
(*c*) Red	60×17.42=	1045.20 kgs.
(*iii*) In traditional wooden boxes:	15×22.15=	332.25 kgs.
		8120.5

(Average No. of oranges per kg is 7.80)

Deduct damages

(*i*) In wire bound boxes:	425 × 0.150 kgs.	= 63.75	
(*ii*) In plastic crates:	35×0.101 kgs.	= 3.54	
(*a*) Grey	15×0.112 kgs.	= 1.68	
(*c*) Red	60×1.002 kgs.	= 6.00	
(*iii*) In traditional wooden boxes:	15×1.002 khs.	=15.03	90.0
Total weight of good oranges			80.30.55
Damages allowed for retail outlets @ 4%			321.220
Quantity booked for sale value			7709.280
Total sale value booked by the Bangalore Horticultural Producers' Marketing & Processing Co-op. Society Ltd., Bangalore, @ Rs. 3.50 per kg.			Rs. 26,982.48

Deduct: Total expenses:

(1) Commission @ 8%	Rs. 2,158.59
(2) Labour @ 0.40 per box	Rs. 220.00
(3) Transportation from Warud to Banglore	Rs. 3,974.00
	6,352.59
Amount received by the orange grower	Rs. 20,629.89
Deduct: Cost of harvesting, packaging, etc.	1,320.00
Net amount realised by the orange grower	Rs. 19,309.89
The price at Warud on 22–11–1984 for 1,000 oranges	200.00
The price for 63,401 oranges	Rs. 12,680.20
The incremental benefits to the orange grower	Rs. 6,629.69

CASE STUDY—IV

Oranges harvested on 7th & 8th December 1984 at Warud, packed on 9–12–1984 and truck left Warud on 10–12–1984 and it reached Bangalore on 12–12–1984. Oranges were sold to the consumers direct in Bangalore and Mysore through the Bangalore Horticultural Producers' Marketing & Processing Co-operative Society Ltd., during 12–12–1984 to 20–12–1984.

Type of pack	No. of boxes	No. of oranges in each box	Total No. of oranges
Wire bound boxes	1	56	56
"	19	64	1216
"	28	72	2016
"	84	80	6720
"	38	92	3496
"	277	100	27700
"	119	120	14280
"	14	144	2016
"	12	165	1980
"	7	180	1260
Total	599	Av. 101	60740

At Bangalore:

Total weight of oranges (net) received: 8086 kgs.
(Av. No. of oranges per kg is 7.5)

Deduct damages:	417 kgs.
Weight of good oranges:	7669 kgs.
Total sale value booked by the Bangalore Hort. Producers' Marketing & Processing Co-op. Society Ltd., at Rs. 3.50 per kg.	Rs. 26,841.50
Deduct total expenses:	
(1) Commission @ 8%	Rs. 2147.32
(2) Labour @ Rs. 0.40 per box	Rs. 239.60
(3) Transportation from Warud to Bangalore	Rs. 3800.00
	Rs. 6,186.92
Amount received by the orange grower:	Rs. 20,654.58
Deduct: cost of harvesting, packing etc.	Rs. 1,200.00
Net amount realised by the grower:	Rs. 19,454.58
The price at Warud on 10—12–1984 for 1000 oranges:	Rs. 275.00
The price for 60,740 oranges:	Rs. 16,703.50
The incremental benefit to the orange grower:	Rs. 2,751.08

CASE STUDY—V

Oranges ware harvested in Warud on 11th, 12th & 13th December 1984., packed on 12th & 13 h December. Truck left Warud on 14th and reached Bangalore on 16th December. Oranges ware sold to the consumers direct in Bangalore and Mysore through the Bangalore Horticultural Producers' Marketing & Processing Co-op. Society Ltd. during 17th to 30th December 1984.

Type of pack	No. of boxes	No. of oranges in each box	Total No. of oranges
Wire-bound boxes:	13	72	936
"	31	80	2,480
"	16	96	1,536
"	160	100	16,000
"	25	112	2,800
"	140	120	16,800
"	51	165	8,415
"	5	190	950
Total:	441	Av. 113.2	49,917
Plastic crates (red)	12	90	1,080
Plastic crates (yellow)	8	120	960
Solid board cartons	12	72	864
"	14	84	1,176
"	27	90	2,430
"	83	96	7,968
"	3	200	600
Total:	139	Av. 93.8	13,038
Traditional wooden box	5	80	400
"	6	96	576
Total:	11	88.7	976
Grand Total	611		65,971

At Bangalore: Particulars	No. of box	Per pack wt.	Wt. kgs.
(*i*) In wire bound boxes	441	12.57	5543.6
(*ii*) In crates			
(*a*) yellow	8	19.5	156.0
(*b*) red	12	17.65	211.80
(*iii*) In solid board cartons	139	11.7	1765.3
(*iv*) In conventional box	11	17.27	190.0
			7866.70

Total weight of oranges (net) received:
Av. No. of oranges per kg. 8.39 kg.

Deduct: Damages:			
(*i*) Wire-bound box	441	0.96	422.8
(*ii*) Crates (*a*) yellow	8	0.80	6.4
(*b*) red	12	1.00	12.00
(*iii*) Cartons	139	1.146	159.3
(*iv*) Conventional box	11	1.454	16.00
Total damages:			616.5 kg.

Total weight of good oranges:		7250.20kg.
Total sale value booked by Bangalore Hort. Society @ Rs. 3.50/kg		Rs. 25,375
Deduct total Expenses		
(*i*) Commission @ 8%	Rs. 2030.05	
(*ii*) Labour @ Rs. 0.40	Rs. 244.40	
(*iii*) Transport charges from Warud to Bangalore	Rs. 4026.00	Rs. 6,300
Amount received by the orange grower:		Rs. 19,075
Deduct cost of harvesting, packing etc.		Rs. 1,458
Net amount realised by the grower:		Rs. 17,617
The price at Warud on 14–12–1984 1000 oranges:		Rs. 300
The price for 65,971 oranges:		Rs. 19,791
The incremental benefit to the orange grower:		(–) Rs. 2,174

Analysis of loss during transportation: The loss due to driage and damages were calculated for all types of packages for all the consignments. It may be observed from Table—A that the loss in weight on transit as well as loss due to damage was much higher in the trial conducted in April 1984. However, these losses in wire bound wooden boxes were much less compared to the traditional wooden boxes. The loss in weight on transit was 10.35% in wire bound wooden boxes whereas it was 14% in ordinary boxes. The loss due to damage was 8.16% in wire bound wooden boxes and 16.71% in ordinary boxes. When the consignment reached Bangalore, the total loss worked out to 18.15% in wire bound wooden boxes and 30.71% in ordinary boxes. Out of 30 traditional wooden boxes, 25 reached Bangalore in broken condition whereas all but one wire bound

Table III(i) Analysis of Loss during Transportation

	Wire-bound wooden boxes	Ordinary traditional wooden boxes		Total boxes	
Number of boxes	497	30		527	
Particulars	Average weight in each box in kgs.	Total weight in kgs	Average weight in each box in kgs.	Total weight in kgs	Total weight in kgs.
Gross weight in Pandhurna on 4—4—1984 (night)	17.250	8573.250	25.350	760.500	9333.750
Weight of empty box	2.300	1143.100	4.000	120.000	1263.100
Weight of packing material	0.850	422.450	1.000	30.000	452.450
Weight of oranges (net)	14.100	7007.700	20.350	610.500	7618.000
Loss in weight on transit	1.460 (10.35)	725.620 (10.35%)	2.850 (14%)	85.500 (14%)	811.000 (10.65%)
Weight of oranges at Bangalore on 9—4—1984	12.640	6282.000	17.500	525.000	6807.000
Weight of damaged oranges	1.150 (8.16%)	572.000 (8.16%)	3.400 (16.71%)	102.000 (16.71%)	674.000 (8.85%)
Net weight of good oranges:	11.490	5710.000	14.100	423.000	6133.000
Total loss	18.51%		30.71%	30.71%	19.50%

Table III(ii) Analysis of loss during transportation

	Wire bound wooden boxes		Plastic crates (Red)		Traditional wooden boxes		Total boxes
Total load	465		70		30		565
Particulars	Average weight in each box in kgs.	Total weight in kgs	Average weight in each box in kgs.	Total weight in kgs.	Average weight in each box in kgs.	Total weight in kgs.	Total weight in kgs.
1	2	3	4	5	6	7	8
Gross weight in Warud	18.000	8,370.00	21.500	1,505	30.63	918.9	10,793.9
Empty box	2.300	1,069.50	2.000	140	4.900	147.0	1,356.5
Weight of packing material	0.600	279.00	0.500	35	0.700	21.0	335.0
Weight of oranges (net)	15.600	7,254.00	19.00	1,330	25.03	750.9	9,334.9
Loss in weight on transit	0.63 (4.04%)	292.95	0.70 (3.68%)	49	p.90 (3.40%)	27.0	368.95 (3.95%)
Weight of oranges at Bangalore/Mysore	14.47	6,728.55	18.30	1,281	24.13	723.9	
Weight of damaged oranges	0.98 (6.28%)	455.70	1.97 (10.37%)	137.9	5.42 (21.65%)	162.6	756.2 (8.10%)
Net weight of good oranges	13.49	6,272.85	16.33	1,143.10	18.71	561.30	7,977.25
Total loss	10.32%		14.05%		25.05%		12.05%

Table III (iii) Analysis of loss during transportation

No. of packs	Wire bound wooden boxes		Plastic crates						Traditional wooden boxes		Total oranges in kgs
	425		Grey (35)		Yellow (15)		Red (60)		15		550
Particulars	Average weight in each box in kgs.	Total weight in kgs.	Average weight in each crate in kgs.	Total weight in kgs.	Average weight in each crate in kgs.	Total weight in kgs.	Average weight in each crate in kgs.	Total weight in kgs.	Average weight in each box in kgs.	Total weight in kgs.	
1	2	3	4	5	6	7	8	9	10	11	12
1. Gross weight in Warud	16.43	6982.75	28.85	1009.75	23.14	347.1	20.42	1225.2	28.500	427.5	9992.3
2. Weight of empty box	2.300	977.50	2.500	87.50	2.400	36.0	2.00	120.0	4.900	73.5	1294.5
3. Weight of packing material	0.600	255.00	0.500	17.500	0.500	7.5	0.500	30.0	0.700	10.5	320.5
4. Weight of oranges (net)	13.53	5750.25	25.85	904.75	20.24	303.6	17.92	1075.2	22.90	343.5	8377.3
5. **Loss on transit**	0.44 (3.25%)	187.00 (3.25%)	0.60 (2.32%)	21.00 (2.32%)	0.50 (2.47%)	7.5 (2.47%)	0.50 (2.79%)	30.0	0.75 (3.27%)	11.25	256.75 (3.06%)
6. Weight of oranges at Bangalore/ Mysore	13.09	5563.25	25.25	883.75	19.74	296.10	17.42	1045.20	22.15	332.25	8120.55
7. Weight of damaged oranges	0.150 (1.11%)	63.75	0.101 (0.39%)	3.535	0.112 (0.55%)	1.680	0.100 (0.56%)	6.00	1.002 (4.37%)	15.03	89.995 (1.074%)
8. Net weight of oranges	12.940	5499.5	25.149	880.215	19.628	294.42	17.32	1039.2	21.148	317.22	8030.555
Total loss	4.36%		2.71%		3.02%		3.35%		7.64%		4.134%

Table III (iv) Analysis of loss during Transportation
Wire-bound boxes: 599

Particulars	Average weight in each box in kgs.	Total weight (in kgs)
(1)	(2)	(3)
Gross weight at Warud on 10–12–1984	16.8	10063.2
Weight of empty box	2.3	1377.7
Weight of packing materials	0.600	359.4
Weight of oranges (net)	13.9	8326.1
Loss in weight in transit	0.40 (2.88%)	239.6
Weight of oranges at Bangalore/Mysore	13.5	8086.0
Weight of damaged oranges	0.696 (5.0%)	416.9
Net weight of good oranges :	12.803	7669.0

Table III (v) Analysis of loss during transportation

Type of packs	Wire bound wooden boxes (WBB)		Plastic crates Red		Yellow		Cartons		Traditional box (TWD)		Total
No. of box	441		12		8		139		11		611
Particulars	Av. wt. in each box kg	Total wt. kg.	Average in each crate kgs	Total wt. kgs.	Average wt. kgs.	Total wt. kgs.	Av. wt. per carton kgs	Total wt. kgs.	Av. wt. per box kgs.	Total wt. kgs.	Total wt. kgs.
1. Gross wt. in Warud	16.88	7444.08	20.750	249.00	23.05	184.4	14.7	2043.3	23.67	260.37	10181.15
2. Weight of empty box	2.30	1014.3	2.00	24.00	2.40	19.20	1.10	152.9	4.9	53.9	1264.30
3. Weight of Packing material	10.60	264.6	0.500	6.00	0.50	4.0	0.40	55.6	0.70	7.70	337.90
4. Wt. of orange at Warud (net)	13.98	6165.18	18.25	219.00	20.15	161.2	13.20	1834.8	18.07	198.77	8578.95
5. Loss in wt. in transit	0.45 (3.22%)	198.45	0.60 (3.28%)	7.20	0.65 (3.22%)	5.20	0.50 (3.78%)	69.5	0.80 (4.43)	8.80	289.15 (3.37%)
6. Wt. of oranges at Bangalore on arrival (net)	13.53	5543.6	17.65	211.30	19.5	156.0	12.7	1765.3	17.27	190.0	8289.80
7. Weight of damaged oranges	0.96 (6.867%)	422.8	1.00 (5.48%)	12.00	0.80 (3.97%)	6.40	1.146 (8.68%)	159.3	1.454 (8.05%)	16.00	616.5 (7.186)
8. Net weight of good oranges	12.57	5120.8	16.65	199.8	18.7	149.6	11.554	1606.01	15.816	173.976	7250.2
Total loss %	10.08		8.76		7.19		12.46		12.48		10.556

Table A Results of the Commercial Trials

Particulars	Exp. I	Exp. II	Exp. III	Exp. IV	Exp. V
Dt of harvesting at Warud	2.4.84	8.11.84	16.11.84	7.12.84	11.12.84
	3.4.84	9.11.84	to	8.12.84	12.12.84
		10.11.84	21.11.84		13.12.84
Dt. of despatch of truck from Warud	6.4.84	11.11.84	22.11.84	10.12.84	14.12.84
Dt. of arrival of truck at Bangalore	9.4.84	14.11.84	24.11.84	12.12.84	16.12.84
Total No. of oranges	46,296	58,702	63,401	60,740	65,971
Average No. of oranges/kg. in Bangalore/Mysore	6.80	6.72	7.80	7.50	8.39
Loss in weight in transit in per cent					
Ordinary box	14	3.40	3.27	—	4.43
Wire-bound box	10.35	4.04	3.25	2.88	3.22
Plastic crate (red)	—	3.68	2.79	—	3.28
–do– (yellow)	—	—	2.47	—	3.22
–do– (gray)	—	—	2.32	—	
Solid board cartons	—	—	—	—	3.78
Weight of damaged oranges in per cent:					
Ordinary box	16.71	21.65	4.37	—	8.05
Wire-bound box	8.16	6.28	1.11	5.00	6.86
Plastic crate (red)	—	10.37	0.56	—	5.48
–do– (yellow)	—	—	0.55	—	3.97
–do– (gray)	—	—	9.39	—	—
Solid board cartons	—	—	—	—	8.68
Total loss in per cent:					
Ordinary box	30.71	25.05	7.64	—	12.48
Wire-bound box	18.51	10.32	4.36	7.88	10.08
Plastic crate (red)	—	14.05	3.35	—	8.76
–do– (yellow)	—	—	3.02	—	7.19
–do– (gray)	—	—	2.71	—	—
Solid board carton	—	—	—	—	12.48
Prevailing market price per 1000 oranges at the beginning of experiment at Warud in Rs.	225/=	150/=	200/=	275/=	300/=
Price received by orange grower through MPDC Programmes per thousand oranges in Rs.	316.30	321.80	304.58	320.29	267.00
Incremental monetary benefit to the grower for the consignment in Rs.	4,226.40	10,085.46	6,629.69	2,751.00	(– 2174.00

wooden box reached intact without any damage. In this trial the wire bound wooden boxes fared very well.

In the 4 trials conducted during November and December 1984, the loss due to moisture and damages were much less in wire bound wooden boxes, plastic crates and solid board cartons compared to ordinary wooden boxes.

Highlights of MPDC experiments:

The oranges treated with Waxol-0-12 and Benlate has shown very encouraging result, while transporting oranges for very long distances. It has been estimated that the cost of treating 100 oranges would be about 20 paise. The cost of the chemical can easily be compensated by the increase in the percentage of good fruits when compared to those transported untreated.

The wire bound wooden boxes used for 8 truck loads can be transported back in empty form in one truck load. Thus the cost of used wire bound wooden boxes works out to Rs. 2.50 per trip because of its re-usability as against the prevailing cost of traditional wooden box of Rs. 7.00 to Rs. 10/- The introduction of re-usable wire bound wooden boxes would not only reduce the cost of packaging by 75 per cent but would enormously save the scarce forest resources also.

The consumers at Bangalore and Mysore could be supplied with better quality of oranges comparatively at cheaper prices.

Conclusions

The wire bound wooden boxes, plastic crates and solid board cartons fared better than the traditional wooden boxes for transporting oranges from Warud, near Nagpur to Bangalore. However the wire bound wooden boxes have an edge over other packages because of its re-usability and its easy transportability in empty form. The initial investment is also much less. Field trials are under way to study the economics of different packages and its profitability to the growers. A series of further experiments combined with chemical treatments and with different types of packages by MPDC in collaboration with other concerned organisations would prove more beneficial in minimising the post-harvest losses thereby procuring good quality of produce assuring better returns to the cultivators and supplying the same to the consumers at a very reasonable price.

Influence of storage time on quality of mung dal stored in different packaging systems

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ABSTRACT

The protective property of jute bags, polyethylene and polyethylene impregnated jute bags have been evaluated for the packing of mung dal (Phaseolus aureus). Studies carried out for a period of 120 days have indicated that there were minimal changes in the dispersion capacity of dal, total protein content, protein and nitrogen solubility whereas they were maximum in jute bags.

Introduction

Pulse is a very important food item and forms a significant source of protein for the people of India. Pulse is taken mostly in the form of dal (dispersed phase of pulse) as well as in the form of soup. The varietal difference in its cooking quality and the relationship between the cooking quality and chemical constituents have already been evaluated. Packaging is very important because of the wide-spread use of pulses in each section of the consumers. Good packaging also protects dal from deterioration during storage and serves in maintaining good quality of dal over long terms. Modern bio-technology lays more emphasis on the unit packaging system in preference to bulk packaging. Unprotected bulk packaging manifests in rapid deterioration in food quality by promoting the growth of molds and various microorganisms[1]. The present investigation has been carried out to elucidate some of the biochemical and physico-chemical properties howing the performance of the packaging unit which can keep good nutritional qualities of mung dal in long term storage.

Experimental Procedure

Mung dal (Phaseoulus aureus) collected from market was the subject of study. It was stored in Polythene (400 pm), Polythene-impregnated-jute (PIB) and jute bags (JUB) respectively for 120 days. Methods adopted to determine different factors are given below:

Moisture Content: Moisture content of the samples was determined by keeping 25 g of sample in an oven (130±2°C) fo. 1 hour. The samples were cooled in a desiccator and weighed[2].

Cooking Quality: Cooking quality of dal was evaluated according to the method followed by Halick and Kelly for rice samples. A 2 g of a dal sample was cooked with 15 ml of warm (80°C) water in a boiling water bath for 20 minutes. The water was drained off and the cooked grains were weighed to determine the water uptake at that instant.

Grain Weight: Dry weight of grain was determined by weighing 100 stored sound grains kept separately for moisture equilibration and expressing the value on dry basis.

Protein Content: Total protein content of dal sample was estimated according to the standard *kjeldhal* method.

Soluble protein content was estimated by taking a 0.2 g of dried sample. It was boiled in 25 ml of distilled water and 0.25 ml of concentrated glacial acetic for 5 minutes, cooled and allowed to stand for 4 hrs and then filtered. The precipitate was washed with 1 per cent acetic acid and the filtrate was treated exactly in the same way as that of total protein estimation, in order to determine the amount of nitrogen present in the filtrate.

Nitrogen solubility Index (NSI) was determined using the formula given by Hulse,J . H. et. al[3].

$$NSI = \frac{\text{Percent Soluble nitrogen}}{\text{Percent total nitrogen of sample}} \times 100$$

Results and Discussion

Item wise results of the experimentations are presented in the following paragraphs:

Moisture Content (MC):

Dal grains stored in each type of PLY, PIB and JUB bags absorbed moisture from atmosphere with increase of storage period (Fig. 1). However, the increase was the highest (18.21 per cent) in JUB and the least (16.05 per cent) in case of PLY after 120 days of storage. This indicated that the moisture exchange between the space above the stored material in PLY and the environment was insignificant. The shelf-life of the stored product remained almost intact upto 90 days (MC-15.2 per cent) whereas that of PIB and JUB deteriorated only after 60 days (MC=14.01 per cent and 16.50 per cent respectively). Dal stored in PIB and JUB were heavily infested with a dirty appearance and undesirable texture and became unacceptable to the consumers.

Cooking Quality:

Cooking of dal was done in two phases. In the initial phase of cooking, dal grains absorbed water and expanded in volume and thereby the weight

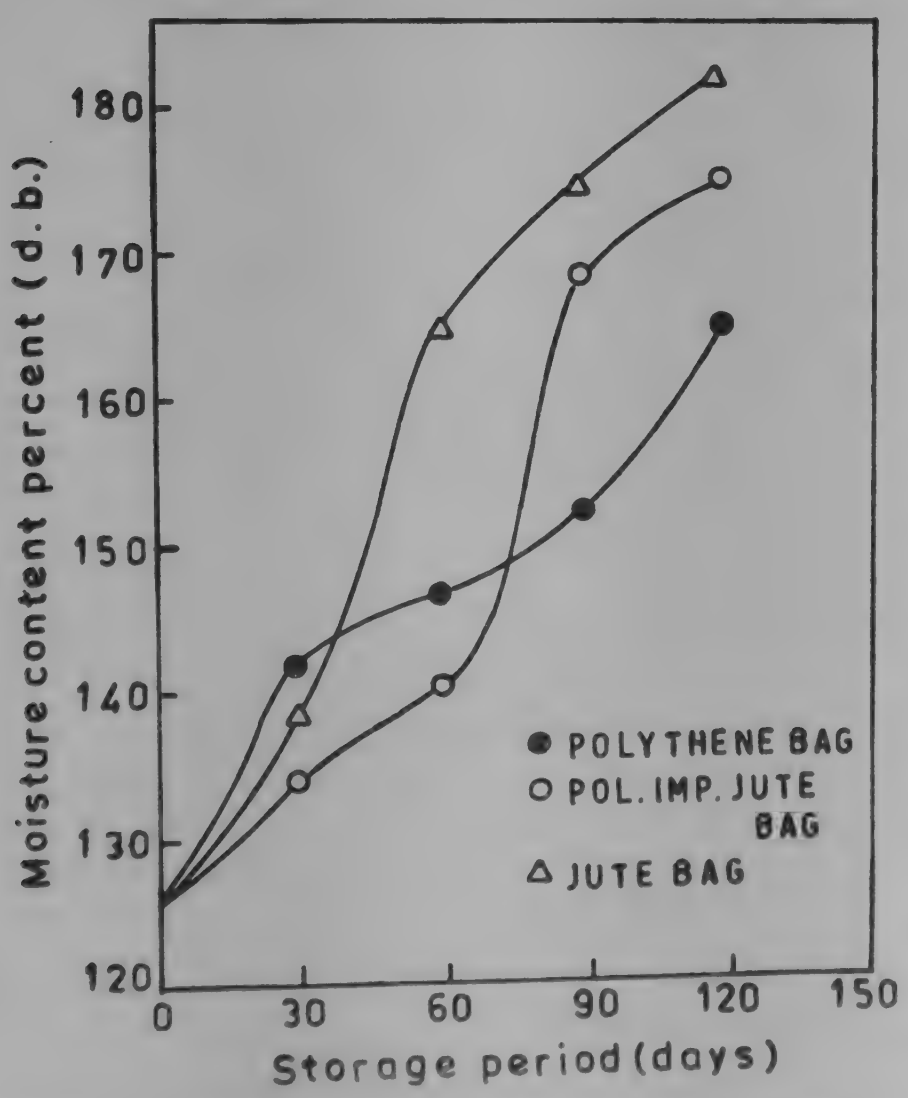

Fig. 1. Moisture Variation of Mung Dal stored in different Packaging systems.

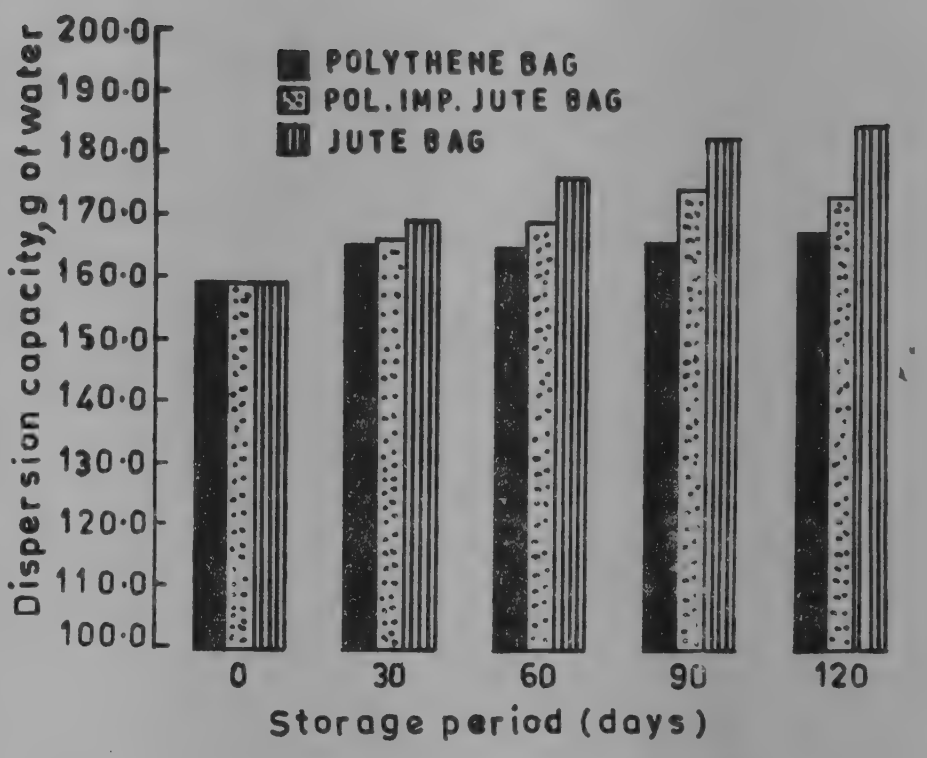

Fig. 2. Influence of storage period on Dispersion capacity of Mung Dal stored in different packaging systems.

increased. But the grains are dispersed at a particular cooking time and the dispersed dal water is actually liked and taken by the consumers[4]. In the present investigation the dispersion capacity of dal was measured in terms of water-uptake values (Fig. 2) for 20 mins in all types of bags. This showed that the dispersion of a definite amount of dal after 20 min of cooking is same and most desirable results was obtained with the material stored in PLY (166.48 per cent). Dal stored in JUB (183.17 per cent after 90 days) showed more dilute dispersed stage of less consistency dal and may not be liked by the consumers.

It is interesting that the diametrical expansion of papad made from blended material (green gram and black gram flours with cereal) showed an increasing trend with storage period[5]. This indicated an improved effect of ageing on the stored blended material necessary for papad preparation. But in case of mung dal the increased water-uptake and dispersion values of the grain stored in PIB, and particularly in JUB is not an index of quality improvement of the food material stored. It was due to the fact that JUB was heavily attacked by insects and microbes during the later part of storage period. A constant dispersion capacity (160-170 g water/g of dal) of dal stored in PLY for 120 days and after 20 min of cooking showed that PLY is the most suitable packaging system to retain the initial quality of the dal, (Fig. 2).

Protein Content:

Pulse proteins are very much important in the sense that the whole protein is taken in the form of

Table 1. Influence of storage time on total and soluble protein of mung dal stored in different packaging systems

Number of days	Total protein, percent (d.b.)			Soluble prctein, percent (d.b.)		
	PLY	PIB	JUB	PLY	PIB	JUB
0	25.03	25.03	25.03	5.85	5.85	5.85
30	25.60	24.85	28.77	5.31	5.23	5.25
60	24.81	25.25	29.64	5.00	4.42	4.94
90	24.70	27.17	24.99	4.69	2.72	1.98
120	24 80	27.52	23.45	4.06	1.375	0.75

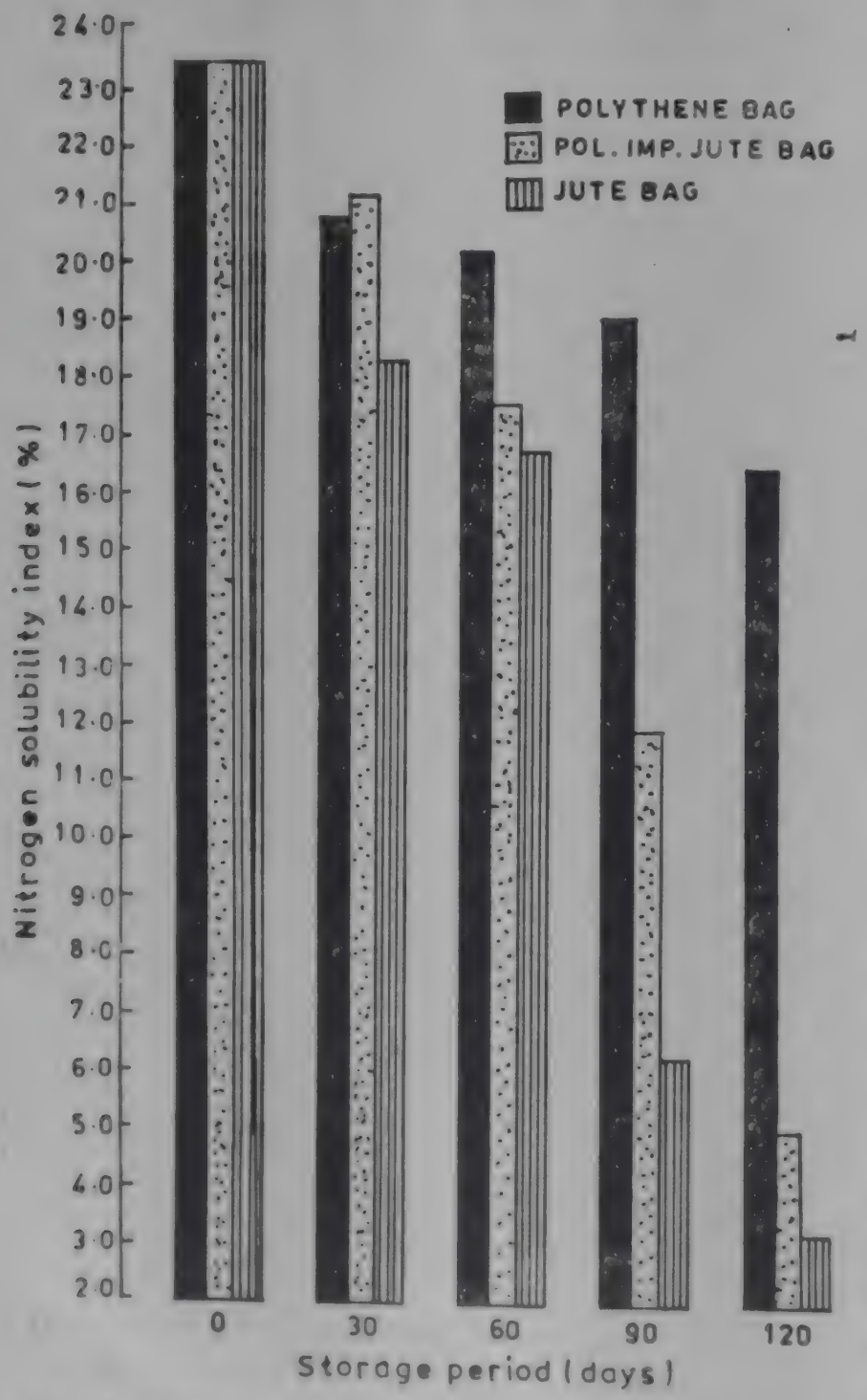

Fig. 3. Influence of storage period on Nitrogen solubility Index (NSI) of Mung Dal stored in different Packaging Systems.

food and the gruel is not thrown out as it is done in case of rice. The total protein of dal (25 per cent) was found to be almost same in PLY, slightly changed in PIB and still more in JUB during a storage period of 120 days (Table 1). The soluble protein (5.85 per cent), on the other hand drastically reduced in PIB, (2.72 per cent) and JUB, (1.98 per cent) during 60 to 90 days of storage, although little change was observed in product stored in PLY (4.69 per cent). The decrease in soluble protein as well as that of enzyme activities in soluble and insoluble portions of the cereals was observed by Primo[6]. Similar results were found to be true in case of dal also as observed by its changes in nitrogen solubility index (NSI) values (Fig. 3). The extent of decrease in initial NSI (23.5 per cent) was found to be much less (16.35) per cent) for dal stored in PLY than that of PIB (5 per cent) and JUB (3.2 per cent). This indicated the better vitality and keeping quaiity of pulse stored in PLY.

Table 2. Influence of storage period on net weight of mung dal stored in different packaging systems

Number of days	Net Weight, g		
	PLY	PIB	JUB
0	1.12	1.12	1.12
30	1.10	1.08	1.12
60	1.03	1.03	1.00
90	0.98	0.92	0.91
120	0.91	0.85	—

Net Weight:

The dry matter as measured by net grain weight of 100 sound grains decreased (Table 2) along with storage time though not very significant. The decrease was maximum in JUB perhaps due to the higher rate of microbial and insect infestation in dal which invaded the solid matters from the dal grains.

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Packaging and Transport of Horticultural Produce in Himachal Pradesh

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ABSTRACT

The Horticultural developments that took place since 1950 and the consequent increasing dependence on forest resources for the wood to meet the packaging requirements of the fruits with the projections on future increases in fruit production in Himachal Pradesh and the demand for packaging requirements are traced. As a measure to curtail the over-dependence on the natural forest resources to meet the requirements for wooden packaging cases for the post-harvest handling and transport of fruits, the various efforts made in Himachal-Pradesh since 1974, by the Horticultural produce marketing Corporation in collaboration with various other organisations, to test the various containers like corrugated fibre board (cfb) cartons, improved wooden containers and also the rigid plastic containers are given. None of them came out to be acceptable in terms of strength to withstand the transit hazards during the post-harvest handling under the existing system, with the exception of telescopic cfb cartons. It is suggested that there is a great need for the development of 'Cold-Chain' for the post-harvest handling of fruits, in which the railways ought to play a vital role.

During the last two decades, Himachal Pradesh has made gigantic strides in the development of Horticulture, and particularly in the production of apple and other temperate fruits like peaches, plums and apricots. The increase in their area and productivity has pushed up the total production and consequently the marketable surplus. All these fruits being perishable and fragile, have to be packed at the place of their production so as to enable them to be transported to distant consuming markets with least damage.

Packaging serves three principal purposes: *(i)* protection to its contents from mechanical injury, insects and pilferage, *(ii)* easy handling and stacking as well as convenience to trade, and *(iii)* appeal to eye and advertisement. When fruits are to be moved to long distances whether by road or rail, they are packed in non-returnable containers and such packages are generally made of wood. Despite modern trends in the use of other materials particularly pulp products, apples and other fruits continue to be packed in wood even though scarcity of wood makes it imperative to shift to some other material

Looking to these needs, H. P. Forest Department has accepted the supply of wood for the purpose of manufacturing boxes for fruits and vegetables as the first charge on the State forests. Besides several other factors, the need of packing cases has greatly increased the burden on the State Forest resources. Further, there seems to be a fallacious conception that the forest resources in these mountains are inexhaustible, permitting exploitation without replacement for decades. Perhaps this mis-conception is one of the important factors responsible for the avoidable continuing use of wood for packing fruits and vegetables.

In Himachal Pradesh, apples, apricots, plums and peaches are the most important temperate fruits but apple holds the top position amongst all these. Tomato and hill-capsicum are the only two vegetables which are sent to different parts of the country in wooden boxes. Although, there has been a marked improvement in the development of floriculture in Himachal Pradesh, so far there is no problem of their packaging and transportation.

Availability of fruits in Himachal Pradesh

The orchards planted till the end of the 5th Five Year Plan have started bearing fruits and those planted upto the end of the 4th Plan have come into full bearing. Whereas the production of fruits, during

the year 1950-51 was only 1200 tonnes, during the year 1981-82 the total production of fruits was estimated at 3.42 lakh tonnes. It may be worth mentioning here that apple by far has remained to be the most important fruit of the region and the production of this fruit alone during 1981-82 was 3.07 lakh tonnes (Table-1) accounting for over 89% of the total fruit production in the State. Figures from 1980-81 to 1983-84 are actuals based on export data, the remaining figures have been projected on the basis of compound growth rates of productivity of actual production for the last few years.

Packages in use and requirement of wood for manufacturing packing cases.

For packaging of apples, which as already stated above, is the most important fruit of the area, five different sizes of boxes are commercially used in Himachal Pradesh (Table-2). Out of these, two sizes of boxes are generally used in Kullu Valley but these are not standardized. The remaining three are being used in other parts of the State. For calculations, 55 boxes of 16 to 18 kgs. capacity can be taken to contain one tonne of fruit. As for stone fruits, there are several sizes of packing cases which are in use but a box containing 7-8 Kgs. of fruit, is the most popular one. Taking this into consideration for packing one tonne of stone fruits, about 125 boxes are required. So far as sub-tropical fruits are concerned, special mention needs to be made in respect of citrus fruits which are also produced in a considerable quantity. But as they are packed in returnable baskets, they have been left out of consideration here.

Although, with proper care and by bringing in

Table 1. Production of Different Fruits in Himachal Pradesh (in Tonnes)

Year	Apple	Other temperate fruits	Nuts & dry fruits	Citrus fruits	Other Sub-tropical fruits	Total
1980—81*	1,18,013	9,264	1,782	4,400	6,369	1,39,828
1981—82*	3,06,798	17,667	1,579	9,345	6,554	3,41,943
1982—83*	1,39,086	15,691	1,081	9,614	12,382	1,77,854
1983—84*	2,57,913	21,859	2,204	12,084	10,215	3,04,275
1984—85	1,70,454*	26,406*	2,224*	15,355**	13,757**	2,28,196**
1989—90**	4,26,186	44,368	8,487	30,696	21,490	5,31,227
1994—95**	4,88,623	54,368	11,009	37,696	29,990	6,21,691
2000 A.D.**	5,56,128	64,368	13,509	44,696	38,490	7,17,191

*—Actuals.
**—Projected figures.

Table 2. Type of Boxes used for Packaging of Apples in Himachal Pradesh

Type of Box	Inner dimensions of the box (cms.) L. B. H.	Grade	Diameter of the fruit (mms.)	No. of fruits per box	No. of fruit layers
Conventional Wooden box (Shimla)	45.7×30.5×30.5	(*i*) Large	75—80	96	4.
	45.7×30.5×27.9	(*i*) Super Large	85 and above	54—57	3.
		(*ii*) Medium	70—75	112	4.
	45.7×30.5×27.4	(*i*) Extra large	80—85	60—66	3.
		(*ii*) Small	65—70	128—132	4.
		(*iii*) Extra Small	60—65	160	5.
		(*iv*) Pittoo	55—60	200—250	5.
Kullu Packing (Dabba)	48.5×20.5×22.5	(*i*) Large	Size grading	63	3.
		(*ii*) Medium	not proper	72	3.
		(*iii*) Small	–do–	96	3.
Kullu Packing (Petti)	48.5×20.5×36.0	(*i*) Extra small	–do–	216	6.
		(*ii*) Extra large	–do–	72	4.
		(*iii*) Super large	–do–	60	4.

better efficiency right from the stage of felling of trees to the ultimate stage of fabrication of boxes, about 70 packing cases of 16 to 18 Kgs. capacity or 100 cases of 7 to 8 Kgs. capacity can be manufactured from each cubic meter of standing volume of wood but at the present level of efficiency only 50 packing cases of apples and 75 of stone fruits can be manufactured from a cubic meter of standing volume of wood. The quantity of wood thus required for the manufacture of boxes, at the present level, which is sufficient for the packing of apples and other temperate fruits is indicated in table-3.

Need for substitute packing cases.

By the end of this century, about 5.64 lakh cubic metres of wood per year would be required for packing of apples and other temperate fruits only (Table-3). If this dependence continues to be on wood alone. the day is not far when the development of fruit industry in the State would be marked negatively. In practice, the difficulty is already being experienced in meeting this heavy and increased demand. In this regard, it may also be noted that natural regeneration of silver fir and spruce, the wood of which is mostly used for making apple boxes, does not establish and as a result the exploitation of these species to meet the increasing demand of wood for packing, is likely to deplete their growing stock significantly. The hill farmer meets his requirements from the forests, be his own or of the Govt., with least regard to the damage inflicted to this natural resource.

The fact that the demand for wood required for packing cases is significantly more than the supply, has been fully appreciated by the Department of Horticulture ever since it came into existence in the year 1970. The Department has been seriously concerned over this problem and has made all efforts to look out for some suitable substitute which could be used in the manufacture of packing cases for the economic disposal of fruits. The problem has also engaged the attention of Government of India who have constituted a committee known as Development Committee for Packing Cases for the purpose. This Committee since its inception in January, 1971 has tried to bring coordination between various organisations like the Forest Research Institute, the Indian Institute of Packaging and Department of Forests as well as Horticulture in H.P., J & K and U.P. Since then, several trials have been conducted on various types of corrugated cartons with and without cell packs and pulp trays. The manufacturers of cartons and various types of boxes also extended their cooperation in such trials. The Regional Research Laboratory, Jammu also supplied fibre board boxes in 1974 for experimentation, but conclusive results could be drawn.

In 1976, the Project had to be abandoned for various reasons. It was restarted next year when the H.P.

Table 3. Requirement of Wood Based on Exportable Production of Fruits

Particulars	1980—81	1981—82	1982—83	1983—84	1984—85	1989—90	1994—95	2000 A.D.
Apples								
Production in ('000) Tonnes	118.01	306.80	139.09	257.91	170.45	426.19	488.69	556.13
Exportable production in ('000) Tonnes	94.41	245.44	111.27	167.79	136.36	340.95	390.90	444.90
No. of Boxes (in lakhs)*	51.93	134.99	61.20	92.25	75.00	187.52	215.00	244.70
Wood required (in lakh Cu.m) 50 boxes per Cu.m)	1.04	2.70	1.22	1.85	1.50	3.75	4.30	4.89
Other Temperate fruits								
Production in ('000) Tonnes	9.26	17.66	15.69	21.86	26.41	44.37	54.37	64.37
Exportable production in ('000) Tonnes	6.49	12.37	10.98	15.30	18.48	31.06	38.06	45.06
No. of Boxes (in lakhs)**	8.11	15.46	13.73	19.13	23.11	38.82	47.57	56.32
Wood required (in lakh Cu.m)@ 75 boxes per Cu.m.	0.11	0.21	0.18	0.26	0.30	0.52	0.63	0.75
Total quantity of wood required in lakh Cu.m.	1.15	2.91	1.40	2.11	1.80	4.27	4.93	5.64

*One Tonne =55 standard boxes **One Tonne—125 boxes

Forest Corporation supplied packing cases made of pine needle boards. This too did not lead anywhere. In 1979 the Forest Research Institute supplied five types of boxes (Table-4) using cheaper and lesser quantity of wood compared to the conventional ones. Lot of defects and difficulties were observed in the use of these boxes and the same were conveyed to the F.R.I., Dehradun for necessary improvements.

During the year 1980, the Department of Horticulture in collaboration with the various institutions (Market Planning & Design Centre, a Joint Project of U.N.D.P., Government of India & F.A.O. of United Nations, Directorate of Marketing & Inspection, Rural Development Ministry, Government of India and Himachal Horticulture Produce Marketing & Processing Corporation.) conducted trials on various substitutes packing cases with the following main objectives:—

1. To establish a common language on quality and size in the trade channels;
2. To establish uniform quality and size standards in different apple producing states; and
3. To examine the possibility of using alternate packages.

During the trial 253 boxes/cartons of five different types (Table-5) were packed at an orchard site, carried on human/mule backs to road head covering a distance of about 3 Kms., and then to Delhi. The packing boxes as well as the fruits were evaluated for their transport worthiness, handling and related parameters. It was observed that tray packed apples in corrugated fiber board (cfb) cartons of either type faired much better than others in respect of damage to the fruit and ultimately the price obtained. It was also observed that Indian cartons were rather better than the imported ones.

Trials conducted on telescopic cfb cartons showed that such containers can be used successfully for the packing of all size grades (Table-6) of apples using appropriate trays and can be transported to distant markets. It may, however, be cautioned that cfb cartons need to be made more sturdy so that they don't lose shape or get softened/soggy under humid conditions. But the trays manufactured indigenously have not been observed to be as sturdy as the imported ones. Therefore, strict quality control on the one hand and sound R and D efforts on the other, would meet the appreciation of all concerned in the marketing of fruits.

Even though the cfb cartons have proven their worth as a good substitute to the conventional wooden box, it will take sometime for it to gain the needed popularity. In the meantime, therefore, efforts have to be continued to evolve a wooden box which might consume lesser wood. As a step towards this direction, the H.P. Department of Horti-

Table 4. Table showing the Damage to Boxes/Fruits during Transit & Pric-E Behaviour of Different types of Boxes (1979)

Type of box	No. of boxes packed	No. of fruits examined	Per cent of boxes damaged	Per cent of fruits bruised/damaged	Price per box (Rs.)
Fir Veneer	20	384	25.00	4.95	47.00
Tun Veneer	20	384	20.00	5.21	47.00
Poplar Wood	20	384	15.00	4.43	52.00
Thin Plywood	20	384	25.00	5.21	50.00
Chir Wood	20	384	15.00	4.69	52.00
Conventional	20	384	10.00	4.43	47.00

Table 5. Table showing the damage to boxes/fruits & price behaviour of different types of boxes (1980)

Type of Box	No. of boxes packed	No. of fruits examined	Percent of boxes damaged	Percent of fruits bruised/damaged	Price per box (Rs.)
Imported tray pack carton	123	1000	25	3.36	60.00
Indian tray pack carton	46	500	—	2.00	59.00
Wooden box with trays	20	250	25	2.80	58.00
Veneer Woven box (F.R.I.)	14	224	—	12.45	56.00
Conventional	50	400	12.50	16.20	51.00

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Table 6. Apple grades and size standards in CFB cartons

Type of box	Grade	Diameter of fruits in mms.	No. of fruits per carton	No. of fruit layers	No. of trays inlcuding topper
Indian Telescopic Tray Pack Carton (500 mms.× 300 mms. × 280 mms.)	1. Super large	85 and above	72	4	5
	2. Extra large	80—85	80	4	5
	3. Large	75—80	100	5	6
	4. Medium	70—75	125	5	6
	5. Small	65—70	150	5	6
	6. Extra small	60—65	175	5	6
	7. Pittoo	55—60	250	Loose packing	—

Table 7. Table showing the damage to boxes/fruits and price behaviour of different types of boxes (1983)

Type of Box	No. of boxes packed	No. of fruits damaged	Per cent of boxes damaged	Per cent of fruits bruised/damaged			Price per box (Rs.)
				Slight	Severe	Total	
Indian Tray Pack Carton	372	1500	8.30	11.00	1.50	12.50	70.00
Improved Shimla	83	1352	16.67	32.06	3.45	35.51	60.00
Veneer Box (FRI)	81	1352	25.00	27.30	1.14	28.44	60.00
Pine Needle Board Box	68	1352	25.00	18.09	3.05	21.14	65.00
Conventional	634	1352	2.20	49.70	4.87	54.57	60.00

Table 8. Table showing the damage to boxes/fruits and price behaviour of different types of boxes (1983)

Type of Box	No. of boxes packed	No. of fruits damaged	Per cent of boxes damaged	Per cent of fruits bruised/damaged			Price per box (Rs.)
				Slight	Severe	Total	
Indian tray pack carton	100	1125	—	4.53	0.89	5.42	87.00
Improved Shimla	200	2040	20.00	13.29	2.20	15.49	67.00
Folding Veneer	100	1040	20.00	16.92	1.15	18.07	70.00
Folding Wooden	100	1040	20.00	16.83	2.60	19.43	67.00
Folding Wooden with trays	9	1044	—	3.58	1.28	4.86	—
Frame (Nailed)	100	960	10.00	20.00	4.17	24.17	71.00
Frame (Metalled)	100	960	10.00	18.02	2.29	20.31	82.00
Conventional	100	2080	5.00	22.12	3.51	25.63	67.00

culture conducted extensive trials during the year 1983 (Table-7) in collaboration with UNDP, IARI, Dte. of M and I, and HPMC. In such trials, 1238 boxes of five different types were used and carried to Delhi market by trucks.

The damage to the boxes was observed to be the maximum (25%) in the case of pine needle board and veneer boxes while it was the least in the conventional wooden boxes (2.2%). Regarding the general condition of fruits, it was observed that only 12.5% fruits were damaged in cfb cartons compared to 54.6% in conventional wooden boxes. Similarly, veneer boxes and pine needle boxes recorded significantly less damage to fruits compared to the conventional one. During the auction of the fruit boxes, the cfb boxes were reported to be sold at a premium of Rs. 5 to 10 per box over and above the others. Physiological condition of the fruits packed in various containers exhibited neither off flavour nor exhibited any Physiological disorder.

Encouraged by the results of the experiments conducted during 1983, the Department of Horticulture repeated the trials during 1984 with greater thoroughness and additions. Eight different types of boxes were used and transported to roadhead and then to Delhi the same day. The results (Table-8)

indicated that cfb cartons and folding wooden type of boxes with trays depicted no damage to the boxes whereas it was observed to be 5% in the conventional type. The damage to other types of boxes varied between 10 to 20%. Perhaps the damage to boxes was caused mainly due to improper loading and stacking in trucks. At Azadpur fruit market Delhi, the cfb cartons fetched the highest price. The physiological condition of the fruits depicted in terms of flesh firmness, TSS and the consumer acceptability, showed that the contents in different types of boxes did not differ significantly.

It is a fact that so far extensive trials have been conducted only in respect of apples. In so far as other temperate fruits are concerned, plum is the most important fruit in this category of fruits and on the basis of specifications provided to the manufacturers, a cfb carton has already been evolved for the packaging of this fruit. Trials will be conducted during the ensuing season with the sample boxes which are being supplied by the manufacturers to examine the transport worthiness of such type of cartons.

For the packaging and transportation of citrus fruits as already mentioned earlier, presently returnable bamboo baskets are being utilized. These baskets are carried in the trucks loaded already with gravels and are transported to nearby markets covering a distance not exceeding 100 Kms. With a view to bringing in efficiency, rectangular plastic containers, which are otherwise used in field boxes for apples, have been tried with success for carriage of fruits in bulk over long distances, as returnable containers. These are otherwise also economical to use in citrus fruits.

It will not be out of place to mention here that the transportation of fruits has to be seen from this point of view that almost 98% or so of marketed surplus produce is being transported by road, only a negligible portion is carried through rails.

Introduction of Cold Chain

For the proper development of fruit industry in Himachal Pradesh establishment of cold chain right from the producing areas upto the terminal markets including ports, so far as export to other countries is concerned, is very essential. In this process railways, which hitherto have not played a significant role in the transportation of the horticultural produce can play an important role by way of developing insulated container service so as to avoid deterioration in transit and take the fruits and other horticultural produce to destination markets in orchard fresh condition.

Post-Harvest Treatments, Packing and Transportation of Cashewapple for Processing:

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ABSTRACT

Total production of cashewnut and cashewapple in India is 1.7 and 8.4 lakhs tonnes respectively. For every tonne of nuts produced roughly five tonnes of cashew apple are available which are at present being wasted. Cashew apples are highly susceptible to injury and rapid microbial detericration. Spoilage organisms in cashewapple were isolated and identified. **Aspergillus niger, Pencillium, Rhizopus and Actinomucor** *were found to be main spoilage organisms. Conditions have been standardised for pre-treatment and packaging for transportation of fruits. Dip treatment in KMS and sodium benzoate solution and steeping in the KMS solution have been found to be effective in reducing the spoilage. Different types of bamboo baskets with or without cushioning and their effect on the spoilage of fruits during transportation over a distance of about 300 kilometers have been studied. Bamboo baskets with large windcws and cushioining with CFB sheets were found to be best for packing cashew apple for transportation.*

Introduction:

Cashewapple *(Anacardium occidentale. L.)* is an important byproduct of cashewnut industry. In India, cashew plantations are mostly concentrated in the states of Kerala, Tamilnadu, Maharashtra, Karnataka, Andhra Pradesh, Goa and Orissa. Production of cashewnut and cashewapple during 1975-76[1] is shown in Table 1. Total production of cashewnut and cashewapple is 1.7 and 8.4 lakh tonnes respectively ie for every tonne of nuts produced, roughly five tonnes of cashewapples are available as by-product. In order to reduce our dependence for raw nuts from East Africa, and increase our capacity to export cashew kernels, Government is encouraging the growers to increase the area under cashew cultivation. Most of the fruit available at present is not utilised. Only about 15% of the fruit produced is reported to be utilised by way of direct consumption. Huge wastage of this nutritious fruit has to be prevented.

There are two main problems which come in the way of large scale utilization of the fruit for direct consumption or for converting into processed products.

They are (1) Cashew apple contains a stringent and acrid principles which causes throat irritation upon eating and (2) It is highly perishable during storage.

Table 1. Area and production of cashewnut and cashewapple in India during 1975—76

State	Area in hectares	Production of cashewnuts (Metric tons)	Production of cashewapple (Metric tons)
Kerala	1,09,198	1,19,212	6,00,000
Karnataka	35,687	15,249	75,000
Tamil Nadu	96,760	10,480	50,000
Andhra Pradesh	31,000	12,600	60,000
Maharashtra	83,413	4,214	20,000
Goa	32,517	7,500	30,000
Orissa	24,487	940	4,400
West Bengal	2,506	—	—
Pondicherry	320	138	500
Tripura	743	17	100
Total	4,16,613	1,70,350	8,40,000

However, to solve the first problem, methods have been developed at CFTRI, Mysore to remove these astringent and acrid principles from the intact fruit[3] as well as from the expressed Juice[4] Delicious and nutritions products such as cashew apple jam, chutney, candy, pickle, vinegar, cashewapple beverage, cashewapple-pineapple and cashewapple-lime blended beverages, cashewapple Juice concentrate etc have been developed[3, 5, 7].

Regarding the second problem generally, fruits and vegetables are highly perishable. It is more so in the case of cashewapple as it is soft, and susceptible to injury and rapid microbiodeterioration during harvesting, transportation and storage. Because of this, heavy spoilage occurs soon after harvesting and before reaching the processing centres. Processors are therefore hesitant to take up cashew apple for processing.

Taking into consideration the nature of the fruit, its susceptibility to injury, special type of packaging containers have to be devised. To arrest the microbial deterioration of injured fruits pretreatments at collection centres are necessary to be developed. Results of the studies conducted in this regard are presented in this paper.

Materials and Methods:

Raw materials:

The cashewapple fruits were collected from Kerala plantation corporation orchards located at Adhur, Cannanoor District. Sound fruits from bulk collection were selected and used for the packaging and transportation studies.

Pre-treatment studies:

The selected fruits were divided into five lots of six kilograms each and the following treatments were given under the field conditions.

1. Control (No treatment)
2. Dipping in chlorinated (50 ppm chlorine) water for 5 min.
3. Dipping in solution containing 1% KMS and 0.05% citric acid for 5 min.
4. Dipping in solution containIng 1% KMS, 1% sodium benzoate and 0.05% cltric acid for 5 min.
5. Steeping in solution containing 0.2% KMS and 0.05% citric acid.

The treated fruits were packed in bamboo baskets respectively, transported to Mangalore, stored for 24 hours and then spoiled fruits from each lot were sorted out and counted.

In the secord experiment, fruits selected as described earlier were divided into four lots of 18 kg each. All the treatments described earlier except for the treatment in chlorinated water were repeated. The treated fruits were then packed in big commercial size bamboo baskets and then transported from Adhur to Mysore. At the end of 24 and 48 hours of storage, per cent spoilage in each basket was determined.

Effect of type of basket and packing on spoilage:

Selected fruits were packed in five types of baskets such as (1) Square type basket (Figure 1) (2) Small baskets with large windows and with and without

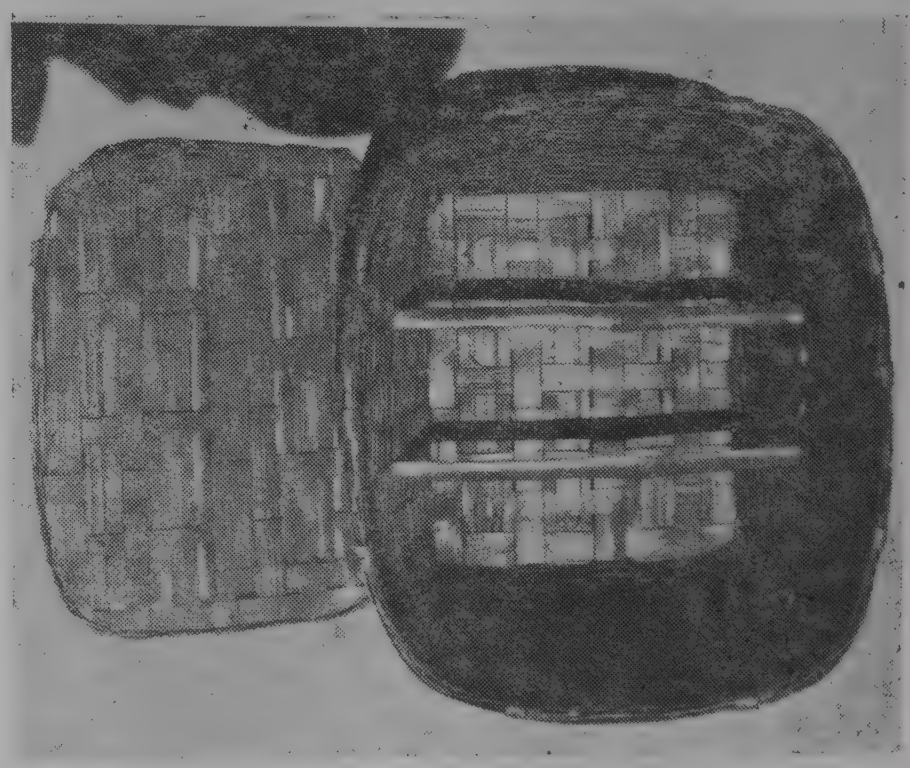

Fig. 1. Square type basket

Fig. 2. Baskets with large windows

cushioning material (corrugated fibre board sheet) at the top and the bottom (Figure 2) (3) Big size baskets with large windows and cushioning material as above (Figure 2) (4) Big size baskets with no windows and with and without cushioning material (Figure 3) and (5) Big commercial size baskets with slits stacked one over the other with no cushioning (Figure 4).

Fig. 3. Baskets with no windows

Fig. 4. Big Baskets, commercially used for packing fruits and vegetables

These baskets along with the fruits were transported from Adhur to Mysore. On reaching the destination, spoiled fruits from each basket were sorted out and the number recorded.

Isolation and identification of spoilage organisms.

Organisms present on spoiled and decaying fruits were transfered to potato-dextrose-agar slants. Fungal isolates from such fruits were serially diluted and purified by pour-plate method using potato-dextrose-agar medium. Genus of the organisms was identified by the morphological characteristics of the isolates.

Results and Discussion:

Effect of pretreatments of cashewapple on prevention of spoilage during transportation and storage.

Data on effect of pretreatments on spoilage during transportation from Adhur to Mangalore and subsequent storage for 24 hours is presented in Table 2. From the Table, it can be seen that in the batch without any pretreatment (control), the spoilage was found to be as high as 70% within 24 hours. Treatment with chlorinated water reduced the spoilage only to 50%.

Table 2. Effect of various pre-treatments of cashew-apples on prevention of spoilage during transportation from Adhur to Mangalore (about 60 kms.) and subsequent storage for 24 hours

Pre-treatment	Batch size size (6 kg.) No. of fruits	Observation at the end of 24 hrs.	
		No. of fruits spoiled	Spoilage %
1. Control	100	77	70
2. Dipping in chlorinated water (50 ppm) for 5 min.	106	53	50
3. Dipping in solution containing 2% Kms. and 0.05% citric acid for 5 min.	100	5	5
4. Dipping in solution containing 1% Kms, 1% sod. benzoate and 0.05% CA for 5 min.	105	Nil	Nil
5. Steeping in solution containing 0.2% Kms and 0.05% CA (fruit to solution ratio 1:1)	102	Nil	Nil

However, dip treatment in 1% KMS solution significantly reduced the spoilage to mere 5%. Dip treatment in the mixture of KMS and sodium benzoate eliminated the spoilage altogether. Similarly steeping transportation in 0.2%, KMS solution also eliminated the spoilage.

For commercial purpose the fruits have to be transported in bigger baskets for longer distances to the processing centres. Bigger, commercial size baskets with a capacity to hold 18 kg fruits were used. The dip treatment in chlorinated water was given up as it was found to be not very much effective. All the other treatments were repeated and then they were transported from Adhur to Mysore a distance of 260 KM. Spoilage at the end of 24 and 48 hours of storage at room temperature was determined. Data obtained is summarized and presented in Table 3.

The Table shows that fruits with no treatment (control) resulted in the highest spoilage of 65% and 100% at the end of 24 and 48 hours of storage respectively. The dip treatment in 1% KMS showed spoilage of 16% and 91% compared to 20 and 64% spoilage in the case of treatment in the mixture of KMS and sodium benzoate solution respectively during the same periods. The data clearly indicate that these treatments are effective only upto 24 hours storage. Regarding steeping transportation of fruits (Treatment No. 4) in KMS solution, it has been most effective in preventing spoilage completely for more that 48 hours. However the limitation of this process is increase in bulk for transportation and necessity of using rigid containers.

Table 3. Effect of various pre-treatments of cashewapples on prevention of spoilage during transportation from Adhur to Mysore (about 260 kms.) and subsequent storage for 48 hours

Pre-treatment	Batch size (18 kg.) No. of fruits	Spoilage % at the end of 24 hrs.	Spoilage % at the end of 48 hrs.
1. Control	340	65	100
2. Dipping in solution containing 1.0% Kms and 0.05% CA for 5 min.	307	16	91
3. Dipping in solution containing 1.0% Kms, 1.0% sodium benzoate and 0.05% CA for 5 min.	294	20	64
4. Steeping in solution containing 0.2% Kms. and 0.05% CA (Fruit to solution ratio 1:1)	305	Nil	Nil

Table 4. Effect of packing cashewapples in different types of bamboo baskets on their spoilage during their transportation from Adhur to Mysore (about 260 kms.)

Type of basket and packing	No. of fruits packed	No. of fruits spoiled	Spoilage %
I. Square type basket			
1. Control	250	72	28.8
2. In between partition-Exptl.	231	60	26.0
II. Small baskets with large windows			
1. Control	117	27	23.1
2. Cushioning with corrugated card-board sheet at the top and bottom-exptl.	99	10	10.0
III. Big size baskets with large windows			
1. Control	190	45	23.7
2. Cushioning with corrugated card-board sheet at the bottom and the top-exptl.	201	26	12.9
IV. Big size baskets with no windows			
1. Control	215	65	30.2
2. Cushioning with corrugated card-board sheet at the bottom and the top-exptl.	200	46	23.0
V. Big size baskets with cross slits stacked one over the other with no cushioning			
1. Lower baskets	264	119	45.1
2. Upper baskets	300	88	29.3
3. Control—basket open with no cover and without any cushioning	288	115	39.9

Effect of type of basket and use of cushioning material on the spoilage of cashewapple during transportation

It is well known that lack of sufficient aeration during bulk transport of fruits produces lot of heat and consequent increase in spoilage. Hence it was of interest to study the effect of providing large number of windows in the baskets and also having cushioning with corrugated fibre board at the bottom and the top. Results obtained in these studies are summarized and presented in Table 4.

It is clear that spoilage reduced to only 26% in the basket with partition as against 28.8% in the control basket without partition. It is also clear that provision of large windows reduced the spoilage to a great extent. Spoilage reduced from 30.2% in baskets with no windows to 23.7% in baskets of same size with large windows. Provision of cushioning material markedly reduces the spoilage further to mere 10.0% and 12.9% in the baskets with large windows. It can also be seen that spoilage is more where number of layers of fruits are more. It was found that most of the fruits in the lower layers of big baskets were crushed and also spoiled. It was clear that having cross slits and stacking of baskets one over the other, though reduced the spoilage in the upper baskets, increased the spoilage in the lower baskets proportionately and hence was not very much beneficial. Hence the data clearly indicate that sufficient aeration and provision of cushioning material is highly helpful in reducing the spoilage during bulk transport of cashewapples over long distances in bamboo baskets.

Isolation and identification of spoilage organisms:

Microbial studies showed that spoilage organisms in cashew apples were mostly moulds. Morphological characteristics of the isolated spoilage organisms indicated that they belong to the genera Aspergillus *Pencillium, Rhizopus* and *Actinomucor.*

Acknowledgement

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Newer Packaging Materials for Black Tea

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ABSTRACT

In view of the increasing shortage and rising cost of conventional packaging material (plywood chest lined with aluminium foil-tissue paper) for packing black tea, there is a need for finding out suitable alternatives to the tea chest-lining material and plywood chest. The recent developments in these aspects of packaging of black tea are discussed in this paper.

Cellulose film (polymer coated, 300 MXXT), metallized polyester film (MPE), biaxially oriented polypropylene film (BOPP), aluminium foil (9μ) laminated to tissue paper and high molecular-high density polyethylene film (HM-HDPE) were found suitable as inner-lining materials for use in plywood chest. Multiwall (5 ply) paper sack having the innermost ply laminated with metallized BOPP or MPE and polythene-lined jute bag were identified as satisfactory packaging materials for black tea. On the basis of the advantage of material handling and low cost, multiwall paper sacks and polythene lined jute bags could be used as alternative packaging materials.

Introduction

The Indian tea industry produced 645 m kg of tea in 1984 and the production target by the end of this century is 1100 m kg. Almost the entire quantity of tea produced in India is packed in the traditional 12-batten plywood chests which are inner-lined with aluminium foil juxtaposed with tissue paper. A standard plywood chest of size $40 \times 50 \times 60$ cm holds, on an average, 50 kg of tea and hence the number of chests required to pack the entire quantity of tea is about 13 million. According to a recent estimate[1] the tea industry uses about 1.1 lakh m^3 of timber in a year for making plywood tea chests and this figure will rise to 2 lakh m^3 by the year 2000 A.D. The indiscriminate felling of forest resources for various purposes, coupled with the diversion of available timber to the manufacture of more lucrative commercial plywood, has created shortage of wood for the production of traditional plywood tea chest and eacalated the cost of packaging. The rise in price of lining material used in conventional tea chest has also contributed to the cost of packaging. At present, the cost of packing tea in plywood chest lined with aluminium foil-tissue paper is Rs. 0.76/kg.

A prominent drawback with the plywood chest is the problem of disposal encountered in the importing countries like U.K. and U.S.A., as the empty chest has very little resale value. A need is, therefore, clearly seen to search for alternative packaging materials for tea.

As a first step, investigations were carried out in UPASI Tea Research Institute, Cinchona to identify alternative lining materials for use in plywood chests and it has been reported that cellulose film (polymer coated, 300 MXXT), metallized polyester film (MPE), biaxially-oriented polypropylene film (BOPP) commercially known as "MM Wrap"' and aluminium foil (9μ) laminated to tissue paper ("Teagard") could be used as alternative to the conventional lining material, *viz.*, aluminium foil-tissue paper.[2, 3] The present investigation was designed to find out the suitability of a new tea chest lining material as alternative to the conventional lining material, and two types of packaging systems as substitute to plywood chest *per se* for packing tea.

Materials and Methods

The storage trials were carried out in one of the tea factories in the Anamalais.

Trial 1 (1982-83):

Multiwall (5 ply) paper sacks having the innermost ply laminated with either aluminium foil, MPE,

metallized BOPP or polythene, supplied by M/s. Warden & Co. Bombay, were tested. CTC-Pekoe Dust (CTC-PD) tea was packed in the test materials and in the conventional packaging material, *viz.*, plywood chest of the size 40×40×50 cm lined with aluminium foil-tissue, as control.

Trial 2 (1983-84):

A lining material for the chest, namely, high molecular-high density polyethylene film (HM-HDPE), known as "Teecare" in trade, supplied by M/s. Kanoi Molecular Products P. Ltd., Calcutta and a chest-substitute, namely, polythene lined-jute bag, supplied by M/s. Jayshree Tea & Industries Ltd., were tested. In this case, CTC-Red Dust (CTC-RD) was packed in standard plywood chests lined either with aluminium foil-tissue or with HM-HDPE film, and in polythene lined-jute bags.

The storage trials were carried out for one year. From the date of commencement of the experiment, the chests/sacks were periodically opened and three replicates of samples were drawn and analysed for moisture content by oven method[4] and theaflavins (TF) by modified Roberts spectrophotometric method as employed by Takeo and Oosawa[5] and Ramaswamy[6]. Parallel set of tea samples were sent to professional tea tasters for organoleptic evaluation.

Results and Discussion

The moisture content of CTC-PD tea packed in multiwall paper sacks with four types of inner-liners in comparison with plywood chests lined with aluminium foil-tissue during storage is given in Fig. 1. Tea packed in multiwall paper sacks with aluminium foil, polythene, MPE and MBOPP gained 4.12%, 2.63%, 1.37% and 1.36% moisture, respectively, over a storage period of 366 days, whereas tea packed in plywood chests lined with aluminium foil-tissue

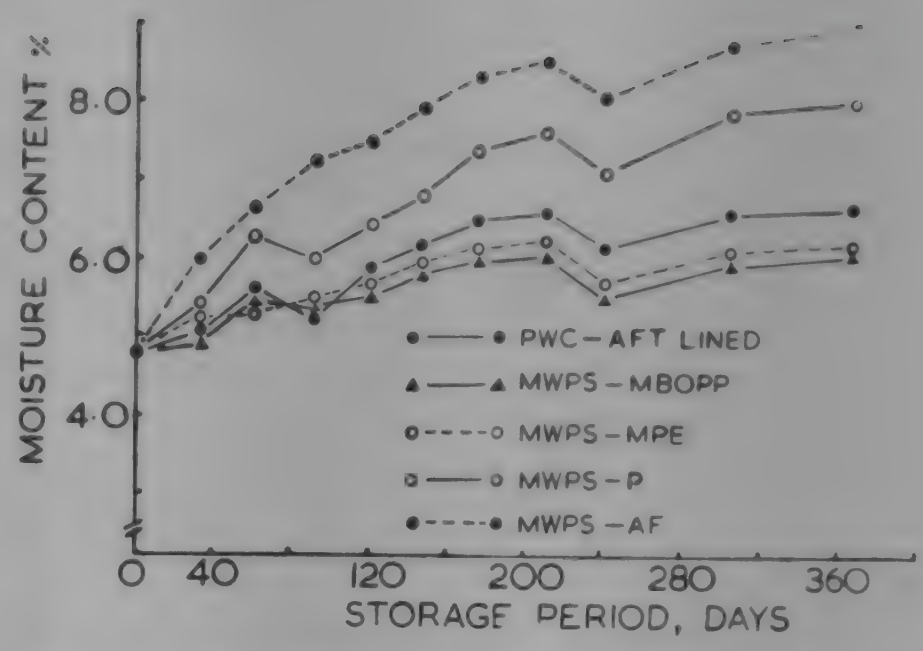

Fig. 1. Moisture content of CTC-PD tea packed in plywood chest and multiwall paper sacks with different lining materials during storage.

picked up 1.83% moisture. Results shown in Fig. 1 indicate that the multiwall paper sacks with MPE and MBOPP liners exhibited better moisture barrier property than the sacks lined with either polythene or aluminium foil and the plywood chest with aluminium foil liner. However, multiwall paper sack lined with aluminium foil does not seem to resist entry of moisture compared to plywood chest lined with aluminium foil. This may be due to the fact that in addition to the poor mechanical properties of aluminium foil (Table 1), multiwall paper sack being a flexible packaging material, permits aluminium foil to crease during handling resulting in less resistance to moisture absorption of tea during storage.

Earlier studies have indicated that theaflavins (TF), a group of polyphenolic pigments which are responsible for briskness, brightness and quality of tea liquor, were found to undergo chemical changes during storage The extent to which this takes place[2,3] depends upon the packaging materials employed

Table 1. Comparative physical and mechanical properties of tea chest lining materials

Properties	Aluminium foil	HM-HDPE film	Cellulose film (300 MXXT)	MPE film	BOPP film
Thickness, μ	20	25	22	12	18
Tensile strength, kg/cm²	875	400	1500	2235	2000
Burst strength, kg/cm²	1.0	N.A.	2.7	5.0	5.0
Elongation, %	1.5	550	15	90	85
MVT rate, g/m²/24 h at 38°C & 90% RH	0.1	1.3	10	2.8	7.3

N.A. = Not available

other conditions like moisture etc being equal. TF content of CTC-PD tea packed in different packaging materials are given in Fig. 2. The levels of TF in tea packed in test materials showed an initial increase up to 90 days and then a declining trend till the end of the trial, which is in line with the findings of Dougan *et al.*[7] and Cloughley[8]. It is also observed from Fig. 2 that the TF content of tea packed in multiwall paper sacks containing either aluminium foil or polythene as inner-lining material showed a maximum in 30 days and started declining thereafter. But, tea packed in other packaging materials showed maximum values of TF in 60-90 days of storage and the decrease in TF levels is also less. This indicates that multiwall paper sacks lined with either MPE or MBOPP and plywood chest lined with aluminium foil-tissue preserve the quality of tea.

The comparative physical and mechanical properties of different tea chest lining materials are given in Table 1. HM-HDPE possesses low moisture vapour transmission rate (MVT rate). Also, it is seen that HM-HDPE film has higher value of elongation per cent than aluminium foil, eventhough its tensile strength is less than that of aluminium foil, thus showing better physical properties, due to which the material may behave well as a lining material for tea chest.

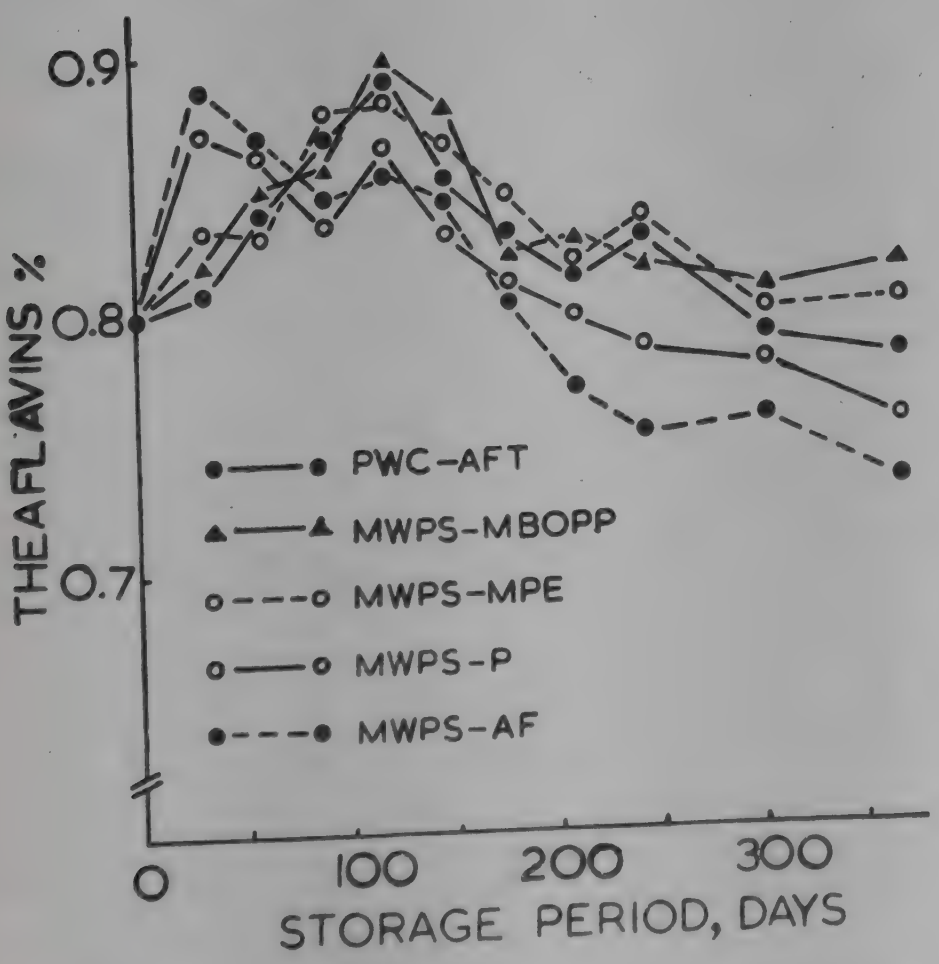

Fig. 2. Theaflavins content of CTC-PD tea packed in plywood chest and multiwall paper sacks with different lining materials during storage.

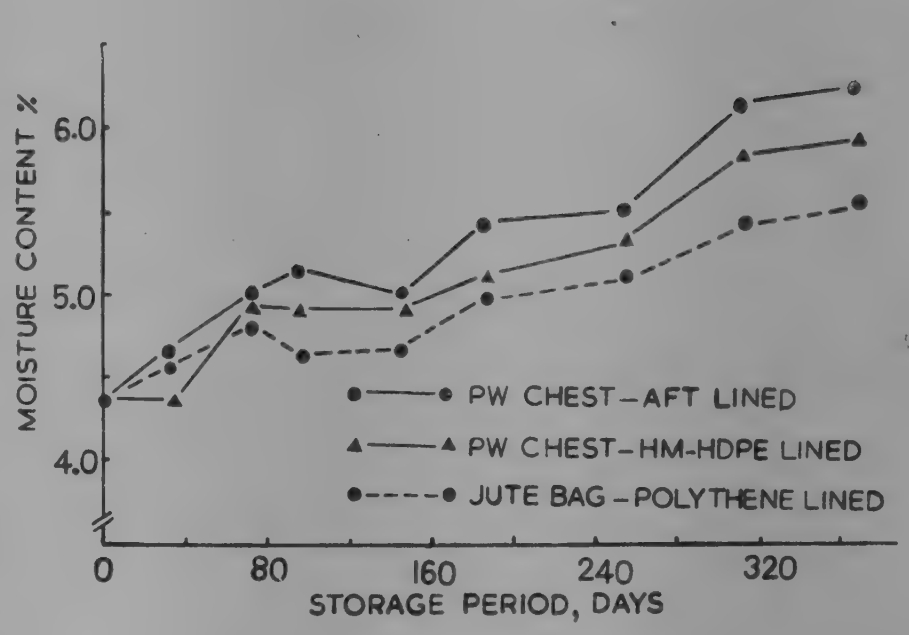

Fig. 3. Moisture content of CTC-RD tea packed in plywood chest lined with aluminium foil tissue or HM-HDPE and in polythene lined jute bags during storage.

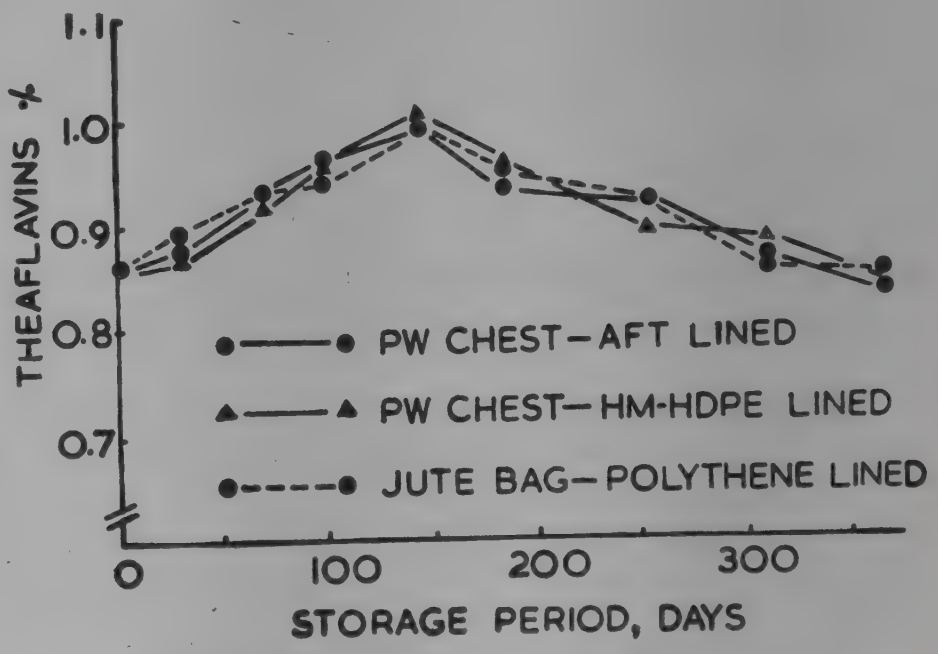

Fig. 4. Theaflavins content of CTC-RD tea packed in plywood chest lined with aluminium foil-tissue and HM-HDPE film and in polythene lined jute bag during storage.

Moisture pick-up of CTC-RD tea packed in polythene lined jute bag and plywood chests lined with aluminium foil-tissue, as well as HM-HDPE film is given in Fig. 3. The jute bag lined with polythene and plywood chest lined with HM-HDPE film are found to have better moisture barrier property than the conventional packaging material.

Theaflavins content of CTC-RD tea packed in polythene lined jute bag and plywood chests lined with aluminium foil-tissue, as well as HM-HDPE film during storage is shown in Fig. 4. The TF content of tea packed in different materials showed an increasing trend initially and started declining thereafter, which is corroborative with what was observed in the case of trial with multiwall paper sacks (Fig. 2). However, tea packed in different materials did not

Table 2. Current market price of different lining materials (Rs./set)

Lining material	Chest size		
	40×40×50 cm	40×40×60 cm	40×50×60 cm
Aluminium foil-tissue paper	4.38 (35.00)	4.94 (37.00)	5.59 (38.00)
HM-HDPE film "(Teecare")	1.25 (31.87)	1.45 (35.51)	1.65 (34.06)
BOPP film ("MM Wrap")	1.42 (32.04)	1.62 (33.68)	2.00 (34.41)
Aluminium foil (9μ) laminated to tissue paper ("Teagard")	2.79 (33.41)	3.22 (35.28)	3.72 (36.13)
Cellulose film ("Trayophane-300 MXX1")	3.18 (33.51)	3.62 (35.35)	4.16 (36.19)
Metallized polyester film	3.54 (34.16)	4.03 (36.09)	4.65 (37.06)

Values in parentheses indicate total cost of plywood tea chests.

show any significant difference in TF levels during storage.

The report from the tasters did not show any trace of taint in teas packed in different materials.

The current market price of different tea-chest lining materials as well as the total cost of plywood chest effected by the different lining materials are given in Table 2. HM-HDPE film and BOPP film are found to be cheaper than other lining materials so far tested and the overall cost of packaging could be reduced by 9-10% if these materials are used in place of conventional lining material.

The cost of multiwall paper sack of the size 112×70 cm having bottom width of 16 cm which holds about 50 kg of tea is Rs. 20/- per sack, whereas the conventional plywood chest of size 40×50×60 cm which holds 50 kg of tea costs Rs. 38/- per chest.

The manufacturers of multiwall paper sacks have given their guidelines for using these materials for packing tea. Paper sacks with tea can be palletised and containerised. According to the reports available from U.K. Tea Association, shipment-trials with paper sacks have produced encouraging results[9]. In addition to being economical, multiwall paper sacks require only one-tenth of timber that is required for making a plywood chest, thereby conserving our forest resources.

The current price of polythene-lined jute bag of the size 105×60 cm which can hold 45 kg of tea is only Rs. 11/- per bag, showing a saving of 68% on packaging. On this basis, jute bags are already in use in a limited way for packing tea for domestic sector, although they lack in aesthetic value.

Acknowledgement

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Studies on the Transportation of Live Clams

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ABSTRACT

Preliminary studies on the packaging of live clams (Villorita cyprinoids) in different ways like dry pack, in water and oxygen and after starving the clams or one day by catching them on the previous day (depuration) were carried out. In most of the experiments the graded size of 46-48 Nos./kg were used for the experiment. It was found that the packaging in 2 kg lots in 400 gauge low density polythene bag with oxygen at a temperature of 20°C could keep them for a period of 4 days in live condition. Temperature seems to be the critical factor in the live transportation of clams. At room temperature both dry and wet pack can be kept for a period of 24 hours only. in dry pack without oxygen and water they can be kept for a period of 3 days in live condition at 20°C. Depuration technique does not appear to be useful in prolonging the storage life of clams in live condition as percentage mortality is more in 48 hr both at 20°C and room temperature compared to the non-depurated samples.

Introduction

Clam is an important edible mollusc found in large quantities in brackish water lakes, estuaries and bar mouths. They occur throughout the backwaters of the coastline of India. In Kerala, Vembanad lake is known to be the richest source of clams. Ashtamudi lake and several other inland water bodies also abound in clams. Two species of clams are encountered in Kerala viz. *Velorita* sp. and *Meretrix* sp. It has been roughly estimated that about 2400 tonnes of clam meat is available from Vembanad lake alone[1]. This together with its availability from several other sources makes up a substantial natural resource of protein food. Clam meat is rich in protein, tasty and is relatively high in glycogen content[2]. (Table 1).

Until a couple of years ago the most important and perhaps the only use to which this natural resource was put was the manufacture of cement and lime from their shells. The meat was a byproduct which was consumed by the local population to a limited extent, large quantities coming in surplus being partly dried for future use and partly wasted. Of late, a good demand has developed for frozen clam meat especially in the Japanese market and this item has found a place among the seafoods exported from 1981 onwards. Export figures[3] of frozen clam meat from India are presented in

Table 1. Proximate composition of clam meat

Protein %	:	7.632—11.05
Fat %	:	0.909—2.17
Glycogen %	:	1.31—7.91
Inorganic phosphorous mg %	:	22.6—29.4
Ash %	:	4.70
Free amino acids mg %	:	
Phenylalanine	:	2.15
Glycine	:	1.32
Cystine	:	0.018
Tyrosine	:	1.87
Histidine	:	2.50
Valine	:	0.09
Lysine	:	3.75
Methionine	:	0.75
Glutamic acid	:	1.40
Isoleucine	:	0.56
Leucine	:	3.08
Serine	:	0.825
Tryptophan	:	0.0112
Proline	:	0.243

Table 2. Exports of frozen clam meat from India

Year	Quantity in tonnes	Value Rs. in million
1981	15.60	0.11
1982	397.43	8.48
1983	546.72	6.71
1984 (7 months)	468.47	Not available.

table 2. The bulk of the product goes to Japan with U.A.E. and U.S.A. lifting comparatively smaller quantities. Sporadic exports of canned and pickled clam meat have also been effected from India in 1981 and 1982 involving small quantities to Japan and UAE. India exported Live fish in 1982 to Kuwait and Srilanka to the extent of 309 Kg earning a foreign exchange worth Rs. 2,392/-. Now there is a good demand from Japan, Italy and other countries for the clams in live condition. One exporter has already air-lifted a couple of consignments of live clams to Japan recently. Enquiries have since been received from both Private Industry and Government Organisations like the Marine Products Export Development Authority for advice as to the best method of packing this commodity for export purposes. The present study is aimed at working out a satisfactory solution to this problem.

Materials and Methods

Clams *(Velorita* sp.) were collected from the backwaters near Perumpadapu, the southern extremity of Corporation of Cochin which forms part of the Vembanad lake. After washing them free of mud and sand in the lake water itself, they were graded for size. In all the experiments the size grade of 46-48 Nos./Kg were used. About 1 Kg of clams were packed in a polythene bag (200 gauge) of the size 30 cm x 18 cm. Each bag was put inside another polythene bag. Half a litre of water collected from the same environment was added to the bag and oxygen from a cylinder was bubbled through it at a positive pressure for a period of 1 minute. The bags were then fastened with rubber band. Each pack was placed inside a waxed duplex carton of the size 34 cm×17 cm in the horizontal position. Eighteen such duplex cartons were packed inside a master carton (5 ply corrugated fibre board) of the size 53 cm×35 cm×30 cm conforming to the dimensions of the OAA packaging standards[4] for wet shipments for the transportation of live fish. The master carton should be of full overlap slotted container (FOL) where all the flaps are of same length. The master cartons were reinforced with two synthetic straps girthwise. In another type of pack viz. the dry pack, individual clams were put in moulded pulp trays in such a way that the free ends of the clams were directed upwards so that they could breathe freely. After packing in the trays of the size 50 cm×30 cm, each tray was packed in a polythene bag with aeration holes and secured with a rubber band so that the clams were not displaced from their moulds. Six numbers of such pulp tray packs were placed inside a 3 ply master carton of the size 53 cm×35 cm×30 cm. The style of the master carton should be regular slotted container. All the master cartons were reinforced with two synthetic straps girthwise, provided two openings on the sides of the cartons upwards and kept in the air conditioned room maintained at 18-20°C. For finding out the mortality at various temperatures, a humidity oven with adjustable temperature was used. Samples were withdrawn periodically to determine the rate of mortality. Twenty clams were removed from the pack and the tip of a sharp scalpel introduced gently in between the shells at the free end opposite the hinge to the extent of a few millimeters so that the internal organs are not damaged. In case the clams were in live condition, they would firmly grip the tip of the scalpel between the shells. The shell would remain in open condition in case of dead clams and would not close when once they are opened.

Drop test:

The finished packs were subjected to a free drop from a height of 1 metre allowing the impact on sides, edges and corners as per I.S. Standard[5].

Yield of meat

To find out the yield of meat after every 24 hours, about 1 Kg of the clams were heated in 500 ml water in a beaker for about 25-30 minutes at atmospheric pressure. After cooling to room temperature, the meat was separated from the shells and weighed in a chemical balance.

Organoleptic test

Organoleptic acceptability studies were carried out on the cooked meat at various intervals during the storage period. The meat collected for finding out the yield was used to find out the acceptability.

Results and Discussion

Table 3 indicates the effect of temperature on the mortality of clams in wet pack flushed with oxygen. It can be seen from the table that the temperature is a very critical factor for keeping the clams in live condition. At room temperature they keep alive for a period of 24 hours only. Under the very same conditions of packing and at a temperature of 18-20°C they kept alive for a period of 4 days. Still lower temperatures are detrimental for the survival of clams.

Table 4 indicates the effect of depuration on the keeping quality of clams. Mortality was 50% for the

Table 3. Effect of temperature on the mortality of clams in wet pack flushed with oxygen (1 Kg clams + 0.5Kg water packed in 200 gauge polythene film)

Temperature	Mortality after			
	24 hours	48 hours	72 hours	96 hours
Room temperature	Nil	75%	—	—
At 23°C-25°C	Nil	Nil	18-20%	—
18°C-20°C	Nil	Nil	Nil	Nil
12.5°C-14°C	100%	—	—	—

Table 4. Effect of depuration on the mortality of clams in wet pack (1 Kg clams + 0.5 Kg water)—Depuration for 24 hours

Temperature	Mortality after	
	24 hours	48 hours
18°C-20°C	Nil	50%
At room temperature	80%	100%

depurated samples after 48 hours in wet pack kept at 18-20°C. It has been observed that for the processing purposes, Live clams should be depurated in water from their natural habitat followed by chlorination at end for elimination of sand stomach contents and microbes[6]. But for transportation in live condition it appears to be better to transport them immediately after catch in wet or dry pack. This may be attributed to the loss of vitality during their starvation for 24 hours.

Table 5 indicates the effect of dry pack on the mortality of clams at different temperatures and different modes of packing. Dry pack in polythene bag secured with rubber band indicates that it can be kept only for a period of 48 hours at 18-20°C. Clams in moulded pulp tray pack with aeration holes can be kept for a period of 3 days in good condition without any mortality and with minimum mortality at the end of 4 days. This may be due to availability of enough oxygen for the individual clams compared to dry pack with all 1 Kg in a single pack where the competition for oxygen is more.

Results of the drop test along with the cost of packaging are presented in table 6. The results indicate that 3 ply corrugated fibre board box (RSC) of the size 53 cm × 35 cm × 30 cm can safely accommodate 6 Nos. moulded pulp tray pack with a gross weight of 11 Kg. In the case of wet pack, corrugated fibre board box (FOL) of the size 53 cm × 35 cm × 30 cm (5 ply) may be used. The container in case of wet pack should be of full overlap slotted style for export purposes to withstand the hazards of transportation.

Table 5. Effect of dry pack on the mortality of clams at different temperatures and different modes of packing

Mode of packing and temperature of holding	Mortality after			
	24 hours	48 hours	72 hours	96 hours
1. Dry pack in polythene bag fastened with rubber band with or without oxygen at RT	Nil	75-90%	—	—
2. Dry pack with or without oxygen in polythene bags at 23°C-24°C	Nil	Nil	90%	—
3. Dry pack with or without oxygen in polythene bags at 18°C-20°C	Nil	Nil	20%	—
4. Tray pack without oxygen at 18°C-20°C with free ends upwards	Nil	Nil	Nil	15%
5. Tray pack with aeration holes in polythene kept at 18°C-20°C with free ends upwards	Nil	Nil	Nil	7-8%
6. Tray pack with clams in downward position (clams in pulp trays with their free end downwards)	Nil	Nil	27%	60%

Table 6. Drop test size of the bulk packaging and cost of the packaging material

Particulars	Gross weight Kg.	Size and style of the CFB	Result of the test	Cost/Kg clams (Rupees)
1. Moulded pulp tray with duration holes in 100 gauge LDPE film	11.0	53 cm 35×cm ×30 cm (3 ply RSC)	No damage to the clams or pulp trays CFB board intact	Rs. 2.40
2. Wet pack (1 Kg clams+500 ml water) in a polythene bag (200 gauge) with oxygen secured with rubber band. Each bag again placed in an another polythene bag secured with rubber board. Each pack placed in waxed duplex carton and 18 Nos. of the duplex cartons packed in a Master carton	30.0	53 cm×35cm ×30cm (5 ply FOL)	No leakage of water or damage to the box	Rs. 2.25

Table 7. Specification of the Master carton used for the transportation of clams

Sl. No.	Type of test	Requirement Upto 20 Kg	Requirement Upto 20-30 Kg
1.	Bursting strength kg/cm² mm	12	14
2.	Water proofness (Cobb/30 minutes)	120	120
3.	Substance gm/m²		
	(*a*) for corrugating medium	170 (3 ply) 150 (5 ply)	170 (3 ply) 150 (5 ply)
	(*b*) for combined wt of liners	400 (3 ply) 450 (5 ply)	450 (3 ply) 500 (5 ply)
4.	Type of flute	A, B, C or any combination of these	A, B, C or any combination of these
5.	Puncture resistance beach units (Minimum)	175	200
6.	Flat crush test 3 ply, Kg/cm² (Minimum)	2.5	2.5

The cost of the packaging material per Kg of clams is around Rs. 2.25 in case of clams packed in wet pack and Rs. 2.40 for those in dry pack. The yields of the clam meat in all the packs were found to be 7.3 to 8%. Organoleptic tests indicated that the material was quite acceptable for 4 days in case of wet pack kept at 18-20°C and 3 days in moulded pulp tray pack kept at the same temperature with ventillation holes.

Table 7 indicates the specification for master cartons for use in live transportation of clams. These have been suggested based on the I.S.I. specifications for master carton for export of frozen seafoods and frog legs (I.S. 6715—1972[7]).

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Performance Evaluation of Packages—Some missing Links

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ABSTRACT

Performance evaluation of packages is an important integral part of package design. Its importance is derived from the fact that it throws light on the protective abilities of the package during the course of the distribution cycle. The closeness of simulation of the actual distribution environment holds the key to success of performance evaluation tests. In the absence of definite and precise knowledge of the distribution environment approximations are made, the basis of which at times tends to be arbitrary. The present paper intends to highlight—these specific areas of arbitrariness which needs to be better understood for making the performance evaluation methods more meaningful.

Introduction

The success of packaging lies in the safe delivery of the packaged product. The environment prevailing in the distribution cycle often poses serious challenge to the protective ability of the package. The various stresses the package has to endure in its course through the distribution system arise mainly out of the journey and the climatic hazards. The acceptance of a package's suitability to a distribution cycle is sought to be achieved through performance evaluation tests. Thus it is now the practice to subject any package to performance tests before finally accepting it for any distribution system. Apart from this, the performance test can be aimed towards *(a)* investigation into causes of damage *(b)* comparison of relative merits of two or more packages *(c)* compliance to statutes, regulations or a chosen standard. This critical assessment of the package is done either by actual field tests or simulated laboratory tests so designed as to reproduce the essential characteristics of the field conditions in the laboratory. Of these, the actual field tests are generally expensive, time consuming and present additional organising problems. Further, their reproducibility is uncertain because of seasonal variations in climatic and traffic conditions necessitating a large number of trials at different intervals of time. In view of these handicaps, the laboratory simulated tests are preferred for actual field tests, since they have the advantage of being less expensive, quick and often reproducible and could be carried out with less number of samples. However, direct extrapolation of the results of laboratory simulated tests to the actual happenings in field conditions is difficult and the laboratory test is generally followed by a field test so that the whole exercise is of some value.

In the following are discussed the present methods of laboratory simulations of distribution hazards highlighting the constraints and shortcomings in their extrapolation to field conditions.

Vibration test

It is common knowledge that in all modes of transport be it by road, rail, sea or air, the package gets subjected to vibrations. The vibration test is used to assess the performance of a package including the interior packing and means of closure when subjected to vibrations, simulated to be typical of the transportation system it has to traverse in. All the standard test methods currently in vogue, concede the difficulties in total reproduction of the vibrations obtained in the transportation environment in its entirety and reconcile to the adoption of a simplified version of the transportation vibration. Such a simulation is characterised chiefly by the production of a vibratory motion having an approximately sinusoidal vertical component and which is reproducible[1].

The procedure followed in brief consists of vibrating the package on an eccentric driven vibration table at a predetermined frequency (normally between 3 to 5 Hz) at a constant amplitude of 25 cms. The

intensity level of vibration given to packages is adjusted to peak acceleration of slightly above 1 G as could be judged by easy insertion of a paper sheet or board underneath the package under vibration.

The standard test methods like the ASTM, D-999 detail the method and procedure to be adopted for testing *(a)* single packages, *(b)* stack of packages, *(c)* for resonance effects, etc. which are common situations for packages during transit.

The duration of the test is sought to be fixed on the basis that a run of 30 minutes on the table in effect is equivalent to 500 miles of actual journey[2].

Apart from the variations in the testing like that for scanning for resonance, shock effects under stack loads, important factors like intensity levels, frequency ranges, duration of the tests, are left to the discretion of the persons performing the test. This necessarily calls for a sound knowledge of the vibration spectra of the distribution environment based on extensive survey data on the prevailing field conditions. Such survey data as available in Europe and America could be accepted only for marine and air transport. The nature and intensity of vibrations in our Railway transportation[3] are fairly well known but for road transportation such information is not clearly available. The main constraint is the highly variable conditions of road and the spring system of transport vehicles.

It is against this background, the force of the following statement is readily felt. If a statistically sound simulated service test is to result, the sampling of the various transportation systems and the interpretation of survey data must be planned and executed on a sound statistical basis. Thus, it is generally held that 'degree of correlation between ASTM and D-999' and the service conditions has not yet been established[4]. Particularly noteworthy is the statement in ASTM 999-9, 'precision and acuracy of these methods cannot be practically determined'.

A way to circumvent the enormity of the task conducting extensive survey could be to simulate the hazard to produce an equivalent effect (damage) during the test (IS 7020—part II-1973). This approach of simulating the damage rather than the vibration environment appears more realistic and feasible when the nature of the damage of the product susceptible to vibration hazard is well known.

The underlying principle of this approach stems from the assumption that product damage might be proportional to energy of vibration and hence for simulating a higher intensity of vibration lasting a shorter duration could be used, the total energy of all oscillations in the test being equal to that of all the oscillations in the actual journey[4].

Studies on this aspect at CFTRI have shown that the vibration test simulating rail transport could be carried out on the valid assumption that equal quantities of damage were produced for equal values of A^2f^3n since the vibration of the carrier and the experimental table were nearly simple harmonic in the vertical plane. Despite the limitations of the work, viz. *(a)* as the inference was based on studies on single layer of packaged goods without getting into the complexities of a multilayered stack, *(b)* approximating all the harmonies to a single simple harmonic motion *(c)* not reckoning resonant conditions and no verification by field trials, the approach can be taken to provide a basis for a better simulated vibration test[5]. Ofcourse, even in this approach, it is essential that the major components of vibration, i. e., frequency and amplitude in a given transportation system is known.

The Compression Test

Any package is bound to experience compressive forces in the course of the distribution cycle. Apart from being a warehouse hazard due to stacking of the packages, the compressive force may also develop in stacks in transport vehicles.

The laboratory test procedures aim at measuring the ability of the container to resist external compressive loads applied from top to bottom or to diagonally opposite edges or corners. This information is sought to be obtained by compressing the package with progressively increasing load applied between two parallel platens of a suitable compression tester.

Although this test indicates the ability of the container to resist compressive forces *per se* the test fails to give a true indication of the package performance under field conditions which differ because of the following factors:

(1) the duration of the time the load is acting (2) influence of moisture content (3) the way the load is borne by the package (stack pattern and pallet profile), (4) previous handlings (5) support provided by fittings and contents.

The variation of the strength among the packages is also a factor to be considered. Taking into account all these constraints, compression test results are sought to be interpreted in terms of safety factors. This introduces an element of arbitrariness, usually safety factors of 1.5 and 5.5[6] are used. For no other types of packages, the effect of this arbitrariness is felt more than in the case of corrugated fibreboard containers. The corrugated fibreboard is a viscoelastic material that exhibits creep which means continuous deformation under the compressive force. Researches on this aspect have shown that the rating for failure duration falls from 100 days to a single day when the compressive load variation is from 75% to 55% of the actual test value. Considerable work has also been done regarding the assessment of the influence of moisture content of the compression strength of the corrugated fibreboard box. The nature of the load to be packaged also contributes to the decision on the safety factor. For fresh produce, a higher safety factor for moisture content effect appears justifiable. Although the nature of the internal fitment could be known, a knowledge of previous handlings could still remain an unknown quality.

The number of packages to be tested, the safety factors to be used depending upon the nature of the packaging material used, the likely stack height, orientation of packages and duration to be endured by the stacks, type of damages when the stack is under vibration would all tend to increase the gap between test and field conditions.

The Impact Test

The packages in the distribution environment are also likely to experience shocks by direct impacts as occurs in handling operations or rail car (switching) shuntings. Accordingly, several test methods are available to simulate and study such effects on the packages in the laboratory.

The Incline Impact Test

The apparatus used has a wooden backstop at the rear end of a two track plane inclined at 10° to the horizontal. A dolly carrying the package is pulled up the inclined plane to a predetermined point and released to roll down the plane ending in an impact against the back stop. For conducting the test, the horizontal velocity and the package orientation are to be predetermined ones. While the latter one condition could be fairly and easily decided, the former one requires a knowledge of the transportation environment. The number of impacts to be given also depends upon the latter.

The test is generally intended for evaluating heavier packages. Opinions differ regarding the limits as reflected in the statements: *(i)* it is usually used on containers weighing more than 300 lb.[7], *(ii)* for packages in excess of 50 lb. an inclined impact test is necessary[8].

The utility of the test lies more in comparing one package with another within the laboratory. The following statements in ASTM test method of 880-89 on the significance of the test are worth noting. However, it has been found that interlaboratory correlation of test results has been poor. This is due in large part to variation design and construction of test apparatus, particularly the back stop. Although the test does not provide fundamental data, it is useful for evaluating and comparing packages.

The test does not attempt reproduction of damage during shunting but only aims at reproducing the velocities.

It has been suggested by Veerraju[3] that the 10 feet release distance which produces about 12 kms/hr velocity used for export trade tests in Europe may be closer to the situation in our developing countries. This velocity falls between the 8 km/hr and 16 km/hr observed in Indian Railways.

The Revolving Drum Test

Wherever the revolving drum test is used, it is worth pondering on the following statement in ASTM D-782-68: "The series of falls is unpredictable and probably no two containers tested will receive exactly the same cycle of abuse". The results may thus vary. Primarily the test can be used only to simulate unpredictable and uncontrolled type of rough handling.

The Drop Hazard

The drop hazard is perhaps the most damaging and most probable hazard for any package during distribution as handling operations and the consequential drops are inevitable. The physical nature of the drop is well brought out in the following statements. The shock due to drop produces transient stresses either over the area of contact or away from it causing damage to the container and some times to the contents[3], the damage of the contents depends mostly on the peak acceleration and duration of impact for long duration impacts and on velocity change for short duration impacts[9].

The test procedure followed prescribes dropping of the packages on a standard drop surface from pre-determined heights on predecided orientations

The choice of the drop height depends on the size and weight of the package and also at times on requirement of a particular specification, and on obvious damage to the contents. Completion of a minimum number of falls from a chosen drop height is as elaborated in ASTM D-775.

Unlike the vibration or incline impact tests, instrumental limitations do not come in the way of a faithful simulation of the drop hazard in field conditions. A thorough knowledge of the handling practices obtained in a given distribution system can help to achieve a realistic simulation mainly by arriving at a judicious choice of such arbitrary factors like the drop height orientations etc. as outlined above. But such a knowledge of the handling conditions obtained in the distribution system are possible only by carrying out extensive field surveys.

In countries like U.K. and U.S.A., such surveys have helped the development of correlations between drop height and package weight applicable to drop hazard like the one proposed by Gordon[9]

$H = 60 - W/3$ (W to a maximum of 30 kg)

Work has also been carried out to establish relationship between drop height and drop number based on the concept of equal damage: $\frac{N_2}{N_1} = \left(\frac{h_1}{h_2} \right)^a$, the value of a lying between 2 and 3[6].

Such formulae, however, have limited utility to the Indian situation where handling abuses are of a more severe nature and where there is not much of rationalisation regarding the package size and weight. The drop test gives an indication of the worst damage possible.

The climatic hazards

There are yet another class of simulated tests on the package performance wherein climatic conditions/ uncertainties representative of the distribution system are reproduced within the laboratory. The major hazards are (1) temperature, humidity and water. In other specific simulations, simulation of light, dust, rain, etc. are also attempted. The simulation of weather conditions necessitates accurately controlled cabinets which are available. Testing conditions to simulate varying climatic conditions from extreme cold to wet tropical conditions are well established (ISO 2233, BS 4826).

But as with the other performance evaluation tests, the major shortfall in these tests are the difficulty regarding simulation of the diurnal changes in temperature to humidities however, with a knowledge of the metereological data the diurnal changes can also be simulated with sophisticated expensive equipments.

Salt Spray Test

No correlation exists between test time and natural exposure time[7].

Sunshine Test

The test simulates natural exposure of 20 days, and is equivalent to 100-140 watts per sq. ft. for 10 days. 45-55% of total energy shall be in wavelength above 800nm.

Table 1 from a recent publication by a Paine packaging gives factors requiring quantification which in a way underscores the missing links so vitally needed for realistic simulation.

The foregoing statement gives in account of the individual performance tests. However, when packages are evaluated for suitability to distribution environments, they are subjected to a "Test plan consisting of a sequence of anticipated hazard elements encountered in various distribution cycles— (ASTM). Such a plan could be effective only when there is a prior knowledge of the nature of the damage that the package and products are likely to incur and also their levels of acceptance. The level of test intensity likely to be obtained in a given distribution system has to be chosen in advance along with the level of damage acceptance. This immediately stresses the need for intensive collection of data on the nature of intensity and frequency of hazards obtained. Distribution Environment Facilities for proper simulation of conditions emanating from such data collection is also essential for a proper test schedule.

Mainly due to the difficulties of exact simulation wide margins are necessarily given and the tests are carried out subjecting the packages to conditions more severe than necessary. The result in the end can be overpackaging and not optimum packaging.

Table 1. Table 15.3. Methods of test and factors requiring quantification

Method of test	Relevant International Standard	Factors requiring quantification
Conditioning	ISO 2233	Temperature, relative humidity, time, pre-drying conditions (if any)
Stacking test	ISO 2234	Load, duration of time under load, attitude(s) of the package(s)! atmospheric temperature and relative humidity, number of replicate packages.
Stack test using compression tester	ISO 2874	Load, applied, duration of time under load, attitude(s) of the package(s).! atmosphertic temperature and relative humidity, number of replicate packages.
Compression test	ISO 2872	Maximum load (where applicable), attitude(s) of the package(s).' atmospheric temperature and relative humidity, upper platen rigidly mounted or free to tilt, number of replicate packages.
Vertical impact by dropping	ISO 2248	Drop height, attitude(s) of the package(s).[1] atmospheric temperature and relative humidity. number of replicate packages, number of impacts.
Horizontal impact tests (inclined plane test)	ISO 2244	Horizontal velocity, attitude(s) of the package(s).[1] atmospheric temperature and relative humidity. profiles of impacting surfaces and use (if any) of an interposed hazard, number of replicate packages.
Rolling test	ISO 2876	Atmospheric temperature and relative humidity, number of replicate packages.
Vibration test	ISO 2247	Duration of test, attitude(s) of the package(s),[1] atmospheric temperature and relative humidity load (if any) superimposed on the package(s), number of replicate packages.
Low pressure test	ISO 2873	Pressure, duration of time at reduced pressure, temperature within test chamber, number of replicate packages.
Water spray test	ISO 2875	Duration of time under spray, attitude(s) of the packages(s).[1] number of replicate packages.

[1]See ISO 2206.

Reproduced from Handbook of Food Packaging—Paine & Paine, p. 384.

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Transport Packaging

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ABSTRACT

Use of different types of master packages, i. e. transport packages based on (i) rigid wooden, plastic and metal containers, (ii) collapsible but rigid when erected, and (iii) flexible paper and plastic bags is discussed in relation to storage and bulk transportation of various foodstuffs. In the field of bulk transport of fruit and vegetables, the advantages of use of corrugated board boxes vis a vis conventional bamboo baskets is discussed.

Transport packages or master packages are normally outer containers in which the commodity in bulk or packed in units are placed to give protection against transit hazards.

These master packs also could be unitised into a Palletised load of 500 to 2000 kgs or loaded into containers of 5, 10 or 20 tons capacity, which ensures minimum handling of the unit packages. The unitisation either in pallets or containers results in considerable economy since the cost of the master pack will be considerably less than for the package designed for transport on its own.

In advanced countries where adequate mechanical handling facilities, loading and unloading facilities are available raw materials are transported in bulk either in rigid containers or containers which can be collapsed after unloading. However, this is not possible in this country due to certain limitations. Eventhen liquid chemicals, oil, bitumin and milk are being transported in rigid bulk containers.

Transport packages could be broadly classified into 3 categories:

Rigid	Collapsible, Rigid When Erected	Flexible
Wooden cases	Wooden crates (wire bound)	Jute Bags,
Wooden crates	Ply wood	Plastic wooden bags
Wooden Barrels	Hardboard	Plastic bags
Plywood containers	corrugated board	Multi wall paper bags
Plastic crate	Composites of above with plastics and Metal	The above with loose liners and or laminated.
Plastic containers		
Metallic crates		
Metallic drums		
Tin containers		
Composite containers		

Indigenous

(1) Bamboo baskets (2) Mud Pots (3) Leaf (4) Straw etc.

With reference to food products, only Processed and ready to eat foods which are consumer packs are packed in *(i)* Rigid containers made of tin, glass and plastic and *(ii)* Collapsible packs made of paper board, corrugated board, flexible bags and pouches made out of paper, plastic and combination of the above. Depending on the nature of protection required by the product namely., protection against ingress of moisture, oxygen, odours, insect attack etc., the necessary properties could be built into the package.

For instance, Polyethylene by itself does not protect the product against oxditive changes and odours. However it is a good water vapour proof barrier. By combining poly with aluminium foil, polypropylene and polyester, or cellophane, the resultant product forms an excellent barrier to oxygen & odour. The consumer unit power are placed in Masterpacks for transport to various destinations.

For semi-processed products such as milk powder a multiwall paper bag or a jute laminated paper bag with a inner layer of water vapour proof material is

used. Bulk items such as soji, and maida are packed in closely woven jute bags or polylaminated plastic woven bags.

The field of bulk transport of fruits and vegetables and fish calls for particular attention since in this area inspite of considerable research work and collection of data the progress is not the same as in the case of packing of processed foods.

During the last 35 years, in various technical seminars conducted by C.F.T.R.I. Mysore and other agencies the wastage of fresh fruits and vegetables are reported to vary from 25 to 35%.

The conventional bamboo basket is predominantly used, Only in the case of apples and oranges we see the use of wooden crates and cases. Grapes are transported in mud pots. Of late we see a difinite trend in grapes in the use of corrugated board packs, for consumer packs of 1, 2 and 5 kgs.

The Govt. is encouraging the use of Corrugated board for packing of apples to conserve forest resources in the area of apple production.

Railways being the major carriers of fruits and vegetables should insist on the use of standardised transport pack whether it is traditional or otherwise. Standards have to be drawn similar on the lines of the association of American rail roads. The proceedings of 'AHARA 1982' contained an article by Sri. P. V. Veeraraju of C.F.TR.I. Mysore, where he points out that by increasing the thickness of the vertical columns strength of the bamboo baskets could be doubled. Instead of only drawing specifications on western oriented packages wherever practicable, we should encourage use of traditional package with such modifications as are necessary to improve the functional properties.

Earlier work done at C.F.T.R.I. has shown that the individual wrapping of mangoes in diphenyl wrappers had minimised the losses due to microbial damage. The diphenyl wrapped mangoes could be packed in reinforced bamboo baskets.

Even though the individual wrapping in diphnyl wrapping may meet with resistance from the trade initially, the Govt. should insist on the same since it minimises losses.

Earlier studies carried out in C.F.T.R.I. on the transport of fruits and vegetables in air-conditioned coaches has definitely established that the losses in transit could be totally eliminated. Even though this mode of transport is expensive compared to normal transport, the reduced losses pays for itself and our national wealth is conserved.

In view of the growing shortage of wood and also to conserve our valuable forest resources we should encourage and even insist on the use of corrugated board and other alternate materials. In addition to having a low tare weight compared to wood corrugated board can be recycled.

Another area where we need to look into is the packaging of fresh fish. The unhygeinic conditions resulting in the melting of ice should be minimised.

We should draw the attention of the Govt. and carriers on the need for adequate packaging to ensure savings in the wastages of food products currently noticed. We should ensure that perishable semi-processed food products and ready to eat foods are transported at minimum cost to reach the ultimate customer in a sound & useful condition. For instance gur or jaggery is currently packed in straw, if it is in the form of cubes and hessian if in the form of blocks. The above packages do not provide protection against moisture. These packs could be improved by inserting a layer of thin polythene film as the inner wrap, before wrapping with straw or hessian.

DISCUSSION

SESSION III—TRANSPORT PACKAGING

Paper 1: Commercial Trials on Transport Packaging for selected Fruits *by L. Krishnaswamy, DMI, Nagpur.*

Q. In a country of eternal shortages, where transport facilities and fuel are in short supply, is it worth considering return of packaging material from the consumers and back to packer? Every such return trip will deprive the product of its chance to move forward to its consumer in time.

I personally feel there is a case to consider seriously to develop 'One time use' packing material which can be disposed of instead of thinking of return of packing material (M.C.S. Swamy, Jamshedpur)

A. The cost on multitrip packs per trip is much cheaper than the single trip packs, though the initial cost is more.

Q. The stackability of empty plastic boxes can be solved by not having straight sides. If the sides are trapezoidal, you can put one empty box inside the other. What difficulties do you foresee in trying this out? (V. Padmanabhan, India Tin Industries, Bangalore).

A. We agree to use such boxes in the trials if any industry is ready to supply them.

Q. If, however, no compromise can be made in the shape, can you try a two piece box, one piece being the base and two sides and the second piece being the other two sides. Please remark.

A. We are agreeable to use in the trials two piece multitrip plastic boxes if they are available in the market.

Paper 2: Recent Developments in Packaging of Black Tea—*by S. N. Stephen Thanaraj, UPASI, Cinchona.*

Q. What is the number of plies used in construction of multi wall paper sack and size to hold 50 Kgs and paper grammage. (J. Sen Gupta, Jardine Henderson, Ltd).

A. It is 5 ply multi wall paper sack of size 112×70 cm. having the bottom width of 16 cms, holds 50 Kg. of tea. Grammage of paper is 80 GSM.

Q. What are the basic construction of base fabric and thickness of polyethylene film for polylined jute bags, its size to hold 50 Kgs?

A. Size of the polyethylene lined jute bag is 110×60 cm. Thickness of the polyethylene lining is 400 gauge. This bag will hold about 40-45 kg. of tea and costs Rs. 11/-per bag. If you want to pack 50 kg. of tea, the size of the bag has to enlarged, which will be unwieldy in size.

Q. What are the transit results of bags of above construction?

A. We have not conducted transit study but we have done only stroage studies. However, U.K. Tea Association, has carried out a number of shipment trials and they have mentioned that due to the lack of stackability, breakage of large grades occur in case of multi wall paper sacks, but they are well within the blending limit.

Q. Can you give the details and specifications of test results obtained?

A. The specifications of multiwall paper sacks have already been given (in the paper prescribed) and the specifications for jute bag have not been laid. It is in progress.

Q. In moisture level graph for tea packed in various packing materials, first moisture increases, then decreases and then again increases in all the packing materials. What is the reason for this phenomenon? (Ashok Garg, Foremost Dairies Ltd, Sharanpur).

A. It is a natural phenomenon that tea picks up moisture during storage. The role of packaging material is to resist the moisture absorption. As I mentioned during the presentation of the paper, we have only to compare with the conventional packaging material whether the test material is superior or inferior to the conventional packaging material which serves as control as I mentioned. It is quite clear from the figures, few materials are superior to the convantional packaging material and we have recommended only such materials.

There is a common complaint against the moisture condensation when tea is packed in polyethylene film than in Aluminium foil/paper laminate. What is the reason? (H. B. N. Murthy, Bangalore).

A. I do not know the reason for this. Mr, Murthy himself said that the polyethylene film is impermeable to moisture. Probably because of this there may be a condensation of moisture. But in case of Aluminium foil/paper laminate the paper might have picked up the moisture released. So there will not be any condensation.

Paper 3: Performance Evaluation—*by A. R. V. Rao, CFTRI, Mysore.*

Q. Drop test can be done in the factory but how to simulate the vibration test in the industry? (H. B. N. Murthy, Bangalore).

A. Vibration test cannot be simulated in the industry but they can procure a model vibration tester at a cost of about Rs. 3,000—4,000.

Mr. P. V. Raju commented that we can carryout vibration test at natural resonance for at least a minimum period of 15 minutes.

SYMPOSIUM SESSIONS

SESSION IV—QUALITY CONTROL AND STANDARDS

Chairman: Dr. P. R. Seshan
Co-Chairman: Dr. M. V. Rama Rao

Rapporteurs: Sri. Srivatsa
Dr. Nasirullah

Phthalate Plasticized Polyvinyl Chloride Films in Food Packaging

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ABSTRACT

Polyvinyl chloride (PVC) based packaging systems for food materials offer many advantages. However, PVC based biomedical devices such as blood bags have been reported to give rise to contamination by Di-(2-ethyl hexyl) phthalate (DEHP), which constitutes upto 40% of the PVC formulation. This phenomenon in conjunction with the bioactivity has made the PVC films suspect for use in packaging system for foodstuffs, especially fat based products.

Considerable information is now available on the biological effects of DEHP ingestion. DEHP is recognized as a mild hypolipidaemic agent. Most often reported observation at different levels of DEHP ingestion with reference to duration, age, sex and species of experimental animals, is the hepatic peroxisomal proliferation and increased activity of the peroxisomal catalase. Hydrogen peroxide production due to the enhanced flavoprotein mediated fatty acid oxidation and its decomposition by catalase are postulated as the cause for observed increase in catalase activity. The role of catalase with reference to the H_2O_2 produced under these conditions are discussed. The carcinogenic potential of DEHP is recognized and search is on for substitutes for DEHP, with lesser biological effects.

Phthalate ester plasticized polyvinyl chloride (PVC) is one of the most widely used plastics in food packaging and medical field. Desirable physical properties such as flexibility, clarity, stardiness, low oxygen permeability, compatibility coupled with relatively low cost, resulted in multifaced usage of PVC ranging from surgical gloves, solution administration sets, transfusion sets, arterial and venous tubing sets for hemodialysis and other extra corporeal devices, to collection and storage bags for blood.

Di (2-ethyl hexyl) phthalate (DEHP), the industrial plasticizer also known as Dioctylphthalate (DOP), finds wider application in PVC formulations as plasticizer. In our country, ISI specified DEHP is commercially available.

Jaeger and Rubin[1] raised concern about the phthalate plasticized PVC, which attracted widespread attention and the hazard due to phthalate leaching from biomedical appliances was realized. Kim et al[2] examined the surface of plasticized PVC material used in blood bags, and found the presence of phthalate, resulting in increased hydrophobicity of the surface. On removal from the surface with methanol it was observed that more of phthalate diffused from the interior of the PVC to again form a surface coating. This phenomenon leads to prolonged leaching of phthalate esters into the stored medium, associated with further repletion from the interitor due to diffusion.

However, the toxicity of DEHP was found to be low, and ADI for man had been worked out to be 1 mg/kg body weight[3]. Albro *et al* analysed and characterized the urinary metabolites of DEHP in the rat[4]. It was suggested that DEHP undergoes hydrolysis in the intestine to its monoester derivative Monoethyl hexyl phthalate (EHP), which further undergoes w-oxidation and (W-1) oxidation in the liver, followed by one round of B-oxidation. Ganning and Dallner[5] reported increased biogenesis of liver peroxisons and mitochondria, and altered activity of peroxisomal enzymes (Table 1).

It was suggested that peroxisonal proliferation may be a result of a cellular response to inhibition of mitochondrial succinate oxidation and hypolipidaemia may in part reflect decreased lipid biosyn-

Table 1. Effect of DEHP on Peroxisomal Enzyme Activities

Enzyme	Specific Activity	
	Control	DEHP
Catalase(*a*)	29.3	17.6
Urate Oxidase (*b*)	0.21	0.13
Octanoyl-CoA Oxidase (*c*)	32.6	195.6
Palmitoyl-CaA Oxidase (*c*)	22.6	111.0

(*a*) Mol. H_2O_2 decomposed. min^{-1}. mg $protein^{-1}$
(*b*) Mol. Urate oxidized. min^{-1}. mg $protein^{-1}$
(*c*) Mol. NAD reduced. min^{-1} mg protein

thesis due to reduced mitochondrial ATP synthesis or increased oxidation resulting from loss of respiratory control[10]. Bell and his coworker[11] showed that DEHP added to incubations of normal tissue *in vitro,* inhibited sterolozenesis and suggested that this could be related to DEHP toxicity to cells in culture. Peroxisome proliferation in primary cultures of rat hepatocytes by DEHP metabiolites was shown by Gray *et al*[12]. DEHP induced enhanced fatty acyl-CoA activity in rat liver peroxisomes was reported[13].

Peroxisomal fatty acyl-CoA oxidation had been shown to generate H_2O_2[14]. However, the induced catalase activity by peroxisomal proliferations was shown to be disproportionably small compared to the H_2O_2 generating fatty acid oxidation[15]. Reddy *et al* postulated that DEHP could be a potential carcinogen because of the generation of harmful oxygen species[16]. The carcinogenic potential of DEHP had been further elucilated by Kluwe *et al*[12].

The peroxisomal B-oxidation system has also been detected in human liver[18]. Recently, hypolipidaemic drug induced hepatomegaly and peroxisomal proliferation had been shown to be delinked in female rats, a conclusion similar to the humans[19]. Also, no studies have been carried out on the uric acid levels of experimental animals exposed to DEHP, which had been shown to affect the hepatic urate oxidase levels. Uric acid had been shown to be a powerful antioxidant and a scavanger of oxygen radicals[20], which could play a vital role in modifying DEHP toxicity.

Materials and Methods

Female rats in the weight range 125-150 grams from the inbred-colony were selected at random and maintained on 20% casein diet for 10 days. They were then divided into two groups of six animals each, and fed with casein diet with or without 2% DEHP for a period of 7 days. At the end of the experiment, rats were killed under mild anesthesia livers were removed and blood was collected. Moisture content of the liver was estimated by drying at 60°C for 24 hours in an vacuum oven. Total lipids were estimated by Folch method[21]. Proteins precipitated by homogenizing liver with cold 10% TCA were washed repeatedly and estimated by the method of Lowry *et al*[22]. Liver catalase was estimated by the method of Cohen *et al*[23]. Liver arginase was estimated by a modified method[24]. Tissue uric acid was estimated by the urate oxidase method[25].

Results and Discussion

Hepatomegaly was predominant in DEHP fed female rats. In our earlier work, we have observed that male rats exhibit hepatomegaly when exposed to 2% DEHP feeding for 7 days. As seen in Table 2 marked decrease in body weight of the experimental rats had taken place, associated with significant decrease in food intake. Loss in body weight is attributed to DEHP toxicity. Table 3 shows that the hepatomegaly noted is not due to accumulation of moisture on fat in the liver. However, significant increase in the liver protein, perhaps due to increased enzyme synthesis has been observed. Experimental rats showed higher catalase activity per unit weight of liver tissue, and also significantly high total catalase activity, because of increased liver weight and protein content (Table 4).

Alteration in arginase activity in rats exposed to hypolipidaemic drying clofiluate was reported[26]. Therefore, liver arginase levels in the animals were estimated. In the reported data, rats were compared with the base line value after 10 days and 30 days of exposure. But, in this experiment, livers of both

Table 2. DEHP Toxicity effects on rats

Rat Group	Body weight gain in grams	Daily Food Intake in grams	Fresh Liver weight as % Body weight
Control	15.2 ±1.38	14.06±0.394	3.95±0.04
Experimental	—5.83±0.31***	8.2 ±0.31***	5.23±0.05***

Mean ± Standard error of mean (SEM)
*** P 0.001.

Table 3. Liver parameters of the rat

Rat Group	Moisture content as % wet weight	Protein content % wet weight	Fat content % wet weight
Control	68.82 ± 0.34	21.55 ± 0.33	6.0 ± 0.03
Experimental	70.42 ± 0.45	24.78 ± 0.21***	6.07 ± 0.04

Mean ± SEM
*** 0.001

Table 4. Hepatic catalase Activity

Rat Group	Activity per gram of fresh tissue in units	Total Activity in Units
Control	$9.58 \pm 0.06 \times 10^3$	$65.62 \pm 0.41 \times 10^3$
Experimental	$14.83 \pm 0.94 \times 10^3$**	$117.60 \pm 7.45 \times 10^3$***

Mean ± SEM

Unit activity is defined as decrease in absorbance by 0.1 in 15 seconds.

** P 0.005
*** P 0.001

Table 5. Liver Arginase Activity

Rat Group	Units per gram fresh tissue	Total Activity in units
Control	$3.31 \pm 0.03 \times 10^6$	$22.67 \pm 0.21 \times 10^6$
Experimental	$3.27 \pm 0.06 \times 10^6$	$25.93 \pm 0.48 \times 10^6$**

Unit of Activity M M Urea liberated/hour/gram tissue.
** P 0.005.

Table 6. Uric Acid in Liver and Serum

Rat Group	% Uric Acid in Liver	Uric Acid in 100 ml Serum
Control	0.09 ± 0.001	3.9 ± 0.02***
Experimental	0.08 ± 0.001	11.3 ± 0.04***

P 0.001

Table 7. Hepatic Residual Catalase Activity after administration of Amino Triazole (1 gm/kg body weight) in Saline ip

Rat Group	Catalase Activity in units per gram fresh tissue	Total catalase Activity in Units
Control	$3.178 \times 10^3 \pm 0.06$	$21.77 \times 10^3 \pm 0.41$
Experimental	$3.5 \times 10^3 \pm 0.05$(NS)	$27.76 \times 10^3 \pm 0.4$***

Mean ± SEM
Unit Activity is defined as decrease
NS: Not significant
*** P 0.001

control and experimental rats, killed at the same time were analysed. Although there is no significant difference in the arginase activities per gram tissue, as expected slightly increased total arginase activity was noticed in the experimental animal (Table 5).

Table 6. depicts the uric acid pattern of serum and liver. Elevated serum uric acid level in the experimental animals is highly significant and needs more study to understand this phonomenon. Urate oxidase levels in the liver need to be studied under these conditions. Table 1. shows that the specific activity of catalase and urate oxidase are altered. Increased peroxisomal B-oxidation as seen in Table 1 leads to increased H_2O_2 production. H_2O_2 produced forms an intermaliancy complex with catalase, which is irreversibly inhibited by Amino Triazole in vivo. Residual catalase activity remaining after Amino triazole inhibition would be a measure of H_2O_2 formed in situ. Table 7, shows that the individual catalase activities in both control and Experimental rats are the same, indicating an increased H_2O_2 generation and subsequent increased inhibition of catalase-H_2O_2 complex in the experimental rats. However the total residual catalase activity is significantly high in experimental animals, due to increased protein content. The work described shows that female rats do not appear to behave contrary to the response of male rats, to DEHP exposure, as previously suggested[19], which warrants further work.

Work is in progress in this laboratory to further our knowledge on this important industrial plasticizer, DEHP.

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Evaluation of Plastic Packaging Materials for Safe Use In Contact with Foodstuffs

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ABSTRACT

In recent years, plastics in different forms have made significant inroads into food packaging. However, improper manufacture and indiscriminate use of these materials may endanger the safety of foodstuffs packed in them for human consumption. This has drawn the attention of all those concerned, particularly the health authorities the world over. For regulating their use many developed countries, after considerable study, have formulated standards and codes appropriate to the conditions in those countries.

As the migration of the chemical constituents/additives of the packaging materials into the food is likely to render the food unsafe for human consumption, it is generally accepted that a quantitative measure of the migrants into the food under actual use conditions (with a knowledge of the toxic nature of the additives) give a fair estimate of safety.

In recent times, foodstuffs are increasingly distributed in prepackaged condition. A wide variety of packaging materials are used for the purpose. They can broadly be classified into 1) paper and paper products (2) glass ware (3) metal-tin and aluminium (4) wood, (5) Synthetic resins-plastics and (6) miscellaneous. Of all these packaging materials, plastics are the late comers but have made significant inroads into food packaging. Plastics, due to their good barrier and strength properties, either singly or in combination with other plastics; aluminium foil or paper offer functional and cost advantages and hence could displace the conventional tin, glass, foil for packaging of many foodstuffs. Besides, many plastic based coatings are used on tin, aluminium and paper and board containers to improve their surface properties.

To improve the conversion and other characteristics of these plastics, many chemicals such as plasticizers stabilizers, surface active agents, lubricants, antioxidants, colourants, mould release agents, antistatic agents, antifogging agents, U. V. absorbers, *slip* agents, and foaming agents are added. Also, the plastics contain low molecular weight components such as monomers and oligomers. Some of these components and additives are reported to be toxic. Their migration into the foodstuffs from the contacting plastic renders the food toxic, eventhough the basic polymers by themselves do not.

Indiscriminate use of plastics or plastic based coatings in contact with food stuffs may endanger the food hygiene and safety for human consumption. World over this has drawn considerable attention of scientists, nutritionists, sociologists, politicians, consumer organisations and above all, the health authorities. For regulating their use, many developed countries, after considerable studies have formulated standards and codes for the manufacture and use of these materials in contact with foodstuffs, appropriate to the conditions and situations in those countries.

In India also, the use of plastics for food packaging has increased and is increasing very fast. But here, the cost, instead of quality is the main consideration for the selection of packaging materials. This consideration has often led to unethical manufacturing practices, such as addition of large percentage of recycled plastics and cheaper non-food grade additives or polymers into the food grade polymer at the conversion stage. Of late, the dangers to human health arising from the indiscriminate use of these plastics for food packaging are recognised and efforts are being made towards formulating regu-

lations for their use. But they are largely based on those of the developed countries, whose use conditions differ very much from India. It is necessary to make them relevant to our climatic conditions, distribution patterns, consumer habits and consumption pattern, toxicity tolerances, socio-economic situations and general technological capabilities.

It is well known that all materials are toxic if consumed in sufficient quantities. Hence, only those materials which are known to produce no accute toxicity and carcinogenesis are listed as safe (positive list)and are allowed to be present in food packaging materials. In the light of new findings these lists are reviewed. The clinical and toxicological evaluations on these materials are based on the nutritional standards, consumer habits and consumption pattern in the country.

Further, even these less toxic materials are allowed to be present only in quantities less than the specified limits considered safe and necessary for the manufacture of the specific plastic formulation. Hence the need for a code of manufacture for plastics. The packaged foods become unsafe or contaminated only if the chemical constituents additives migrate into the foodstuffs beyond a limit. The evaluation of the safety can best be done by clinical trials using experimental animals fed on the packaged foods. But because the clinical tests are too time consuming and too expensive, analytical test methods are resorted to. It is generally accepted that a quantitative measure of each migrant into the food gives a fair estimate of the safety and hence limits for the migrants are considered. These limits are fixed depending on the ADI[1] (Accepted Daily Intake) of the additive present in the plastic and the quantity (Q) of food consumed or the area (A) of the packaging material coming in contact with the food consumed.

Migration limit in mg/litre. = ADI/Q in litres.

in mg/cm^2 = ADI/A in cm^2

and ADI = NEL/F

Where NEL=No Effect Level based on 90 day animal feeding trials and F is the factor of safety which can be anywhere between 100 to 1000. It is this factor of safety that may have to be decided from the socially acceptable risk of any unfavourable effect at levels of consumption by the highest consumers of the packaged foods into which the substance migrates.

The measurement/or estimation of individual migrants (specific migration) in the foodstuffs is extremely difficult and laborious as against the estimation of all the migrants together (global migration) which is relatively simpler. Even this global migration is difficult to estimate in actual foodstuffs which are generally complex. Hence, foodstuffs are categorised into few groups like high fat foods. alcoholic foods, acid foods,aqueous foods, etc., and solvents to simulate the extractive character of each of the food types are chosen with appropriate simulation factor, to render easy estimation and reproducibility. The global migration includes the migration of non-toxic substances also. However, if the limit for global migration does not exceed the limit of any of the migrants from the plastic it may still be safe. But the actual global migration limits, generally agreed upon are only compromises.

Table. 1 gives the global migration limits specified by a few of the important regulating agencies of the world. From the table, it can be seen that the nature of the test and the limits are not uniform in all the countries. Japan[2] and USA[3] have given different migration limits for different types of plastics. The regulation of Food & Drug Admin. (FDA) USA covers a wide range of plastics and clearly specifies for each plastic material either migration or extraction test depending upon the manner of their use for food. Its part 177: polymers-Indirect additives covers numerous polymers such as polyolefins, acrylics, nylons, polyesters, vinyls, thermosets, polycarbonates, ionomers, sealing gasket, cellophane, chlorosulphonates and others. Further parts 175 & 176 give specifications for adhesives, resinous coatings, coated papers and other substances for use as components of coatings.

The FDA (USA)[3] and British plastic federation (BPF)[4] specifies (Table 1) only hexane and xylene extraction limits by refluxing for polyolefin resins when used singularly and only migration limits when used as coatings or laminates. Indian Standards[5] prescribed this extraction requirement earlier, but substituted this requirement by global migration limit in its new IS specification[6]. The reflux extraction tests are much simpler and can be expected to reflect the amount of degraded portions of the recycled materials in addition to other additives. Because of this, the reflux extraction test for polyolefins appears to be more relevant to Indian situation where there is likelyhood of addition of too much of recycled material to the virgin polymer (as in the case of largest used plastic—the polyethylene).

Hence, it is desirable to study the scientific basis and significance of the tests and the limits given under various regulations on migration and extraction before developing standards/regulation to suit the Indian conditions.

Table 2 gives specific migration limits for heavy metals and volatile toxic monomers such as vinyl chloride in PVC, styrene from styrene based plastics, acrylonitrile from nitrile plastics and non-volatile monomers from thermosets. Even here, the limits vary from country to country. Japan[2] has fixed limits for the migration of heavy metals for all plastics and monomers for some whereas, ISI has fixed migration of heavy metals only for PVC.

Table 3 gives categorisation of foods and the corresponding simulants to be used in the migration tests. FDA (USA)[3] and Japan[2] have categorised foods into typical groups like acidic and non-acidic aqueous foods, oils and fats, fatty foods, dairy products, alcoholic beverages, dry solids with and

Table 1. Global Migration Limits

Sl. No.	Country	Global migration limits.	Limits for extraction by refluxing
1.	ISI-[6,7,9] India	60 mg/kg. or 60 mgs/liter or 0.1 mg/cm^2 for containers of capacity less than 250 ml. (for polyethylene[6] PVC[7] & poly styrene[9])	5.5% in hexane & 11.5% in xylene for polyethylene (Now discontinued)
2.	EEC[10] Europe	60 mg/liter or 60mg/kg. or 0.1mg/dm^2 for all plastics & laminates.	Nil
3.	BPDF[4] (UK)	3μg formaldehyde/sq. cm in melamine formaldehyde.	5.5% in hexane and 11.5% in xylene for polyethylene; 6.5% in hexane & 10.0% in xylene for polypropylene.
4.	Japan[2]	150mgs/liter for PE PP & 30 mgs/liter for containers to be used above 100°C. 15-30 mgs/litre for nylon. 240 mgs/liter for poly styrene.	10 ppm of potassium permanganate consumption for water extract for all plastics.
5.	Code of Federal Regulations,[3] DAF-USA 1983.	50 mgs/liter or 0.5 mgs/sq. in (0.08/sq. cm.) for all plastics and coatings and for sizes below 1 gallon.	(*i*) 5.5% in hexane & 11.3% in xylene for PE. (*ii*) 6.4% in hexane & 9.8% in xylene for PP. (*iii*) 1.0% in ethyl acetate & benzene for nylon. (*iv*) 0.15% in water 1.50% alcohol & n-heptane for polycarbonates.

Table 2. Limits of Monomer & Heavy Metals in Plastics

Sl. No.	Country	Limit for MONOMER	Limit for Heavy metals
1.	ISI-India	VCM in PVC-1 ppm; in food migration-10 ppb Styrene in polystyrene-2000 ppm	Pb 1 ppm and others 0.01 ppm in PVC.
2.	EEC-Europe	VCM in PVC-1 ppm	Nil
3.	BPF-UK	VCM in PVC-1 ppm. styrene in PS-5000 ppm.	Nil
4.	Japan	VCM in PVC-1 ppm.. Volatile component in polystyrene-5000 ppm. Vinylidine chloride in PVDC-6 ppm. Caprolactum in Nylon-15 ppm.	(*i*) 100 ppm Dibutyletin & 1000 ppm cresyl phosphate in PVC. (*ii*) Pb, Cd & Ba 100 ppm each in PVDC. (*iii*) 0.05 ppm Antimony & 0.1 ppm Germanium in PET.
5.	FDA-USA	VCM not specified Styrene in PS—10,000 ppm & fatty foods contact-5000 ppm, Acrylonitrile in Acrylonitrile in ABS plastics-11 ppm.	Nil

Table 3. Food Simulants and Categorization of foods

Sl. No.	Country	Simulants	Food classification
1.	ISI-India	(*a*) Distilled water (*b*) 3% acetic acid (*c*) 8% alcohol (*d*) 80% alcohol (*e*) Hexane (*f*) Heptane	Make appropriate choice. Use all solvents in case of despute
2.	EEC-Europe	(*a*) Distilled water (*b*) 3% acetic acid (*c*) 15% alcohol (*d*) Rectified olive oil or sunflower oil or standard synthetic triglyceride	Nil
3.	BPF-UK	Nil	Nil
4.	Japan	(*a*) Distilled water (*b*) 20% alcohol (*c*) Heptone (*d*) 4% acetic acid	For all foods For liquors & spirits. For oils, fats & fatty foods For all other foods
5.	FDA-USA	(*a*) Distilled water (*b*) Heptane (*c*) 8% or 50% alcohol	For acidic & nonacidic aqueous products, Dairy products non-alcoholic beverages & bakery products. For oils, fats, Dairy products & aqueous products containing free oil For alcoholic beverages containing 8% or more of alcohol

Table 4. Time-Temperature Conditions for Migration Tests

Sl. No.	Country	Condition of test	
1.	ISI[8]-India	(*i*) 60°C for 2 hr. brief contact high temperature (*ii*) 40°C for 24 hr.-long contact Room temperature (*iii*) 40°C for 30 minutes-Hexane (*iv*) 25°C for 30 minutes-Heptane	Water, 3% acetic acid, 8% or 80% alcohol
2.	EEC[10] Europe	70°C for 2 hrs-Accelerated 40°C for 10 days—simulating long term room temperature storage for all simulants	
3.	BPF[4]-UK	Same as EEC	
4.	Japan[2]	60°C for 30 min. with acetic acid, alcohol, water 25°C for 60 min. with heptane 95°C for 30 min for use above 100°C.	
5.	FDA-USA	121°C—2 hr. with water-sterilising temperature 66°C—2 hr. with water & 8% alcohol-Hot filled or pasteurised below 150°£. 49°C—24 hr. with water-Room temperature & 8% alcohol filled & stored 38°C—30 min. with heptane-Hot filled or pasteurised below 150°F. 21°C—30 min. with heptane-Room temperature filled & stored.	

without fat, and specified typical simulants for these categories. ISI[8] has stipulated many food simulants but without categorising the Indian foods.

It has indicated that the choice of the simulating solvent shall be dependent on the nature of the food and in case of dispute, the threshold value of migration shall be satisfied for all solvents and with all test conditions. It may be noted that ISI is the only one to give hexane as one of the simulants, whereas FDA (USA) is the only one not to give acetic acid as a simulant. Thus, there is a need to study and categorise Indian foods and specify the right type of simulant for the migration tests.

Table 4 gives time-temperature conditions specified for migration tests. As can be seen from this table, the temperature-time combinations are highly divergent even for the same use condition from country to country. For example FDA (USA)[3] specifies 120°C for 2 hours for high temperature-heat sterilisation, whereas Japan[2] specifies 95°C for 30 minutes for sterilisation above 100°C and IS has no suggestion for this condition. For room condition storage FDA (USA) specifies 49°C for 24 hours whereas Indian Standard specifies only 40°C for 24 hrs for our hotter climate. Similarly for migration with heptane Japan specifies 25°C for 60 min, whereas IS[8] specifies 25°C for only 30 minutes. In the light of this, the test conditions given in Indian Standard appear to be lower.

As the migration of constituents increases exponentially with temperature[11] the test temperature should always be equal or more than the worst use condition, whereas the longer time of contact (as in long storage) can be simulated by a lesser contact time (laboratory test time) using higher temperature. In this regard there is a definite need to review the time-temperature condition for migration tests and formulate conditions of tests as close to use condition in India as possible or atleast to simulate them.

The test procedures and apparatus suggested for the global migration differ from country to country. In all the procedures, the quantity of migrant is determined by evaporating the simulant after extraction and weighing the residue. Extractive quantities generally being in the order of a few milligrams per dm^2, of the area of the test material exposed, the accuracy of the tests will be enhanced by exposing larger area to the simulant and measuring the residue from the entire extractant. FDA (USA) suggests a total area nearest to 180 sq in (1165 cm^2) for each of the quadruplicate test samples enabling the use of a common analytical balance for weighing the residue whereas ISI[8] specifies exposure of only 70 cm^2 area and use of only 30 cc of the total 140 cc of the extractant, to measure the migrant. This necessiates the use of a micro-balance and needs extraordinary care. If the area exposed is increased to about say 1,000 cm^2, the tests can be conducted in many analytical laboratories without special facilities like the microbalance and without losing accuracy.

The global migration from a given surface of the plastic depends greatly on its surface area exposed and very little on the volume of the extractant in contact provided the concentration of the migrant in the extractant is small. This means that the migrant concentration in the extractant (simulant) when expressed as mg/L will depend much on the ratio of the surface area of contact to the volume of the simulant. ISI test method[8] specifies this ratio to be 0.5 (1 sq. cm^2: 2 ml). However, in actual usage this ratio can be as high as 5. Under this condition, the concentration of the extractive in the content (extractant) will be far higher (almost five times) than that obtained under the test. This situation has been taken care in FDA (USA) which specifies the test using the finished container giving the limits in both mg/cm^2 and mg/L. If sheet material is tested the concentration of the extractant mg/L is extrapolated to the actual surface area to volume ratio of the finished container. This portion of the procedure can usefully be adopted in the Indian Standards.

In order to make the test procedure and apparatus more meaningful, practicable and simpler, one may have to specify only the procedures in general and suggest/indicate the apparatus. The procedures may specify the minimum surface area to be exposed and its ratio to the volume of the simulant if tested in sheet form or may specify filling the actual container to the normal level and also the migrant limits, both in mg/cm^2 and mg/L, for different solvents.

With regard to the test apparatus, the regulation should specify only the critical requirements and the broad conditions to be fulfilled to follow the specific procedure. The details may be left to the ingenuity of those, in appropriately using the facilities at their disposal for the test. At the most, the specification may only suggest a detailed apparatus. For easy implementation of the regulations, the specified test procedures and apparatus have to be consistent

with the general technological capability and practicability.

Since the last few years there is a spurt in the introduction of many more flexible plastic laminates and plastic bottles for consumer packaging of foodstuffs in India. Also the general awareness towards their safety for using them in direct contact with foods has increased very much. As a consequence, the formulation of regulatory measures has become the need of the day. However, these regulatory measures have to be preceded by the development of suitable test methods (procedures and apparatus) to be incorporated into the regulations for effective control. At present there are no regulatory measures incorporating specific test procedures for the purpose. The ISI method[8] covers only partially and even the existing standards as discussed earlier are not very relevant to the Indian situations. The limits of extraction are to be worked out and the test methods are to be developed in relation to the needs and conditions in the country. For this purpose a few surveys and studies are to be made.

A survey of the nutritional standards, toxicological tolerances, consumer habits and the levels of consumption and an analysis of the socio-economic cost-benefit are to be made for working out the limits of migration.

The proximate compositions of all the Indian food stuffs that are now packaged and are likely to be packaged in future, have to be compiled and study made to categorise them. Their active components which are likely to penetrate into the plastics are to be identified for the selection of relevant simulating solutions, and simulating (accelerating) factors are to be established by experimental study of the migration both in the predominant active ingredient and in the simulant.

In India the ambient temperature conditions vary widely and the temperatures inside warehouses reach as high as 60°C at the roof level. The ambient temperatures and their duration in different parts of the country are to be collected/collated from the meteriological charts and the temperatures obtained in warehouses and retail shops are to be measured at various locations to get an idea of the temperature conditions in the country. The temperature acceleration factors for extraction by different simulant solvents are to be investigated to evolve accelerated test methods. This sort of study also helps in developing methods of extrapolation from one time-temperature condition to another and facilitates grouping of the time-temperature conditions obtained in actual use.

The laboratory facilities and skills generally available in different regions of the country are to be looked into to evolve test procedures and methods that are simple enough to be used at the laboratories in different regions without sacrificing accuracy.

Above all, a critical study of the development of the present status of all the regulatory measures followed by different countries is necessary to gain an insight into the whole problem of safety of packaging materials for food contact use.

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DISCUSSION

SESSION IV—QUALITY CONTROL AND STANDARDS

Paper 1: New trends in the use of plastics in packaging—*by P. R. Seshan, I PCL Vadodara*

Q. Can IPCL take the lead in representing to the govt authorities for reduction in import duties on newer plastics such as ionomer which can help in raising packaging standards? (Vijay Toley, Rollatainers Ltd, Faridabad).

A. If there is representation by the processors, we may also be associated with such an effort.

Q. Can plastic crates be used in a manner similar to intermodal containers for transportation of apples, oranges etc.?

A. Already NDDB is using such trays. Efforts are being made to introduce collapsible trays also.

Q. Can a certificate be used by IPCL for their PVC of the grade K-55/56 for VCM content? (A. P. Singh, Caprehans India Ltd, Bombay).

A. It is all manufactured by latest technology. We can give a certificate for VCM. It may be below 1 ppm level.

Q. Can PVC resin withstand IR sterilization without making change in its compounding process?

A. I do not have any ready answer for this.

Q. Could you tell the comparative rates of filling of film containers compared to metal containers? (M. M. Khullar, TCIL).

A. I am afraid I may not have any ready answer.

Q. The food industries in the S. S. Sector are forced to buy flexible packages from the open market because the processors refuse to cater to orders of less than 50 kg. How are we to make out whether the raw material used is virgin or recycled? (V. R. Gooty, Food Folks, Mysore).

A. I think it is a very difficult question to answer. You have to go by trust or faith. By colour, it is very difficult to distinguish the recycled and virgin one. We can request the processor to buy from reputed polymer suppliers and distributors.

Q. Do you think PVC containers with a lining material as moisture barrier will be useful for packing tea as a bulk packaging material as alternative material to the conventional packaging material namely, plywood chest?
(S. N. Stephen Thanaraj, UPASI Tea Res. Inst. Cinchona).

A. PVC or LDPE or PP liner can be used. It is difficult to fabricate a container out of PVC and it may not be the suitable material.

Paper 2: Phthalate plasticized Polyvinyl Chloride Films in Food Packaging—*by S. Jayaraman, DFRL, Mysore.*

Q. Has the FAO/WHO methodology been followed to assess carcinogenicity? (D. Rajalakshmi, CFTRI, Mysore).

A. The data given are by the National Toxicological Programme. We have not carried out the carcinogenicity study, as the cost is enormous.

Q. What is the estimated level of pickup of DEHP in foods by 6 months of storage with various types of foods? (Shanthi Narasimhan, CFTRI, Mysore).

A. It varies. Plasticizers are lipophilic in nature. Hence, it is not recommended to pack highly fatty foods.

Q. The results expressed by you and the American studies are contradictory. Where do we stand on this issue? (P. R. Seshan, IPCL, Baroda).

A. Still, the last word is not said about this. The amount of H_2O_2 & catalyst available decide the carcinogenicity. DEHP is not based on genetic metabolism.

Q. Is the plasticizer DEHP available in India?

A. Yes, we can get it from Amines & Plasticizers Ltd, Bombay.

Paper 3: Evaluation of packaging materials for safe use in contact with food stuffs —*by P. V. Raju, CFTRI, Mysore*

After the discussion it was concluded that any standard for migration and extraction should be properly applied to Indian nutritional levels and Indian types of foods. Further, as environmental conditions vary considerably in India it is to be considered with great care before formulating IS standards for extraction limits.

PLENARY SESSION

NATIONAL SYMPOSIUM ON 'RECENT DEVELOPMENTS IN FOOD PACKAGING'
THE FOLLOWING RECOMMENDATIONS WERE MADE AT THE PLENARY SESSION OF THE SYMPOSIUM

Recommendations

1. The suitability of welded cans for packing processed food products should be explored by the R & D Institutions and industry to realise the advantages of lower cost and elimination of lead contamination, especially in the case of export products.

2. In view of the indigenous availability and recycling possibilities R & D efforts may be made to develop aluminium cans as a substitute to tinplate cans.

3. The polymeric cling films have enormous potential as wrapping materials for fruits and vegetables to enhance the shelf life. The plastic industry should take up its production for commercial use.

4. Infestation being the major problem of most of the packaged foods, R & D efforts to be made to develop insect resistant packaging materials and forms.

5. With the increased use of plastic packaging materials the problems of pollution also increases. Hence, it is suggested to mark instructions on the packages for proper disposal.

6. Aseptic Packaging as a technique is to be welcomed. However, the use of this method for promoting the export of fruit products in bulk packages should be viewed with concern as it cuts down the export of value added products.

7. To conserve timber, it is recommended that for transport packaging of fruits and vegetables, intense efforts should be made to replace wooden packing cases with corrugated fibre board boxes or returnable plastic or wooden crates and other traditional packages.

8. It is recommended that institutions like CFTRI & DFRL should study the safety aspects of food packaging materials, examine the existing methods and standards for the purpose available world over and assist in formulating standards and regulations.

9. It is well recognised that food packaging is a multidisciplinary activity and as such packaging technologists should be exposed to the related areas like sensory evaluation methods, marketing and economics.

It is also suggested that packaging profesionals in food industries should have a stint in CFTRI to have a broader perspective.